POWER PLANT ENGINEERING

Established Over 29 Years

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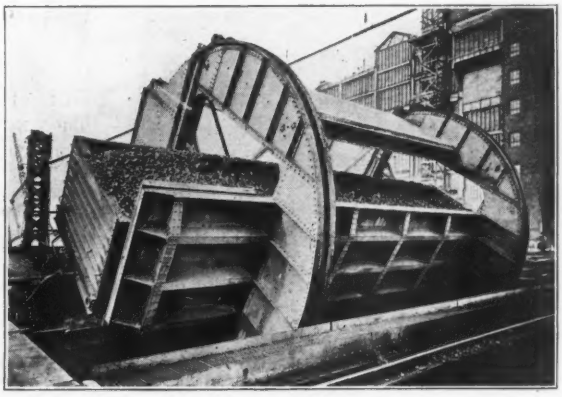


Cradles of One Hundred Ton Capacity

IN YEARS GONE by every home, which was considered at all complete, was equipped with a cradle. It was a means whereby the wrath of the "young hopeful" was often soothed and he was induced to enter the land of nod to behave as all good children should. The modern mother has advanced ideas and, as a result, the cradles of old are now in the second-hand furniture stores.

Engineers, in looking for an inspiration to lower the cost of coal handling, have either reminisced of their childhoods days, when they reluctantly rocked the cradle of their younger brothers and sisters, or they have searched through the relics of used furniture. At any rate, they are now using cradles for unloading coal cars expeditiously in order that the avaricious appetite of the furnaces may be satisfied and thus the boilers soothed into assuming the load imposed upon them by the operators.

Various other practical and economical methods of coal and ash-handling are reviewed on page 785 of this issue.

WILLINGNESS to assume responsibility is a characteristic of the progressive engineer. In so doing, however, he must be willing to acknowledge his errors as readily as he accepts credit for work which terminates successfully. Other characteristics, which form the basis of success in the field of engineering, are advanced in an article by Louis R. Lee, on page 794 of this issue.

Brotherhood of Locomotive Engineers Extends Banking Facilities

NEW BANK BUILDING AT CLEVELAND EQUIPPED WITH A POWER PLANT TO PROVIDE LIGHT, HEAT AND POWER FOR BOTH THE NEW BUILDING AND THE OLD BUILDING WHICH IS LOCATED ACROSS THE STREET. CONNECTION BETWEEN BUILDINGS MADE BY TUNNEL BENEATH STREET. BY R. G. NAIRN

STARTING IN 1920 with a small bank in remodeled quarters at the corner of Ontario St. and St. Clair Ave. in the city of Cleveland, a labor bank for those who gain their livelihood by manual labor spread so rapidly that the deposits increased from an initial $620,000.00 to approximately $27,000,000.00 by 1925. It was a natural development, therefore, to plan on new and larger quarters, accordingly a site for a new building was secured opposite the existing 14-story structure owned and operated by the Brotherhood of Locomotive Engineers.

In the preliminary investigation regarding foundations the conclusion was reached that a mat foundation, which would in effect bring the plane of pressure under each column footing at a uniform elevation, was the most logical construction. This is the first office building in the city of Cleveland to have a monolithic mat over the entire area of the building.

Another phase of the investigation centered around the development of mechanical units to permit the most economical operation of both properties, as it was felt that if modern engineering held any secrets that could be analyzed and developed for the purpose of saving money it should be done. A power plant of sufficient magnitude to supply both buildings was then tentatively laid out and the advantages and disadvantages of engines and turbines considered. Owing to the fact that an office building has such a fluctuating power load, due principally to elevator service, it was found necessary to have a prime mover that would have the inherent ability to carry out the function of taking these momentary overloads, without causing any flickering of lights, as current for both machines and lights is from the same generator, but is split at the switchboard into 220 and 110 v. respectively. This led to the selection of high efficiency engines, direct connected to generators, with large flywheel.

Since the combined heating requirements of the two buildings totaled over 92,000 sq. ft. of radiation, it was seen that a non-condensing prime mover would be of immense value because the exhaust steam could be used for heating. This aspect being thoroughly and satisfactorily studied, the boiler plant auxiliaries and coal storage facilities were decided on and with the addition of an armored vault at the upper basement level, the street elevation was planned. From the 2nd and 19th floors, inclusive, commercial office space has been provided for the use of the public.

Supply Pipes Located in Attic

Immediately above the 19th floor is located the attic space where all the main supply lines for steam heat, hot water, cold water and drinking water are located. A careful study was made to keep all the piping as high as possible, which resulted in a storage space worth a great amount of money. Surmounting the attic is a roof garden, the first in Cleveland on top of a skyscraper to be open to the public.

Elevator machines are in a line with the rear of the building and the control contactor panels, which are immediately in front, are set up on a concrete shelf about 12 in. above the machine floor. Immediately opposite on the other side of the room are the motor generator sets for the variable voltage control system.

The older building which formed the nucleus of the brotherhood's growth is an office building with one basement level, a main floor devoted to stores, restaurant and offices, 12 office floors and an attic floor above. It also has incorporated in it an auditorium with a seating capacity of 1200 people. The elevator installation of course is of an early type, the building being 14 years old. The drive for each elevator is from a basement type machine; the elevator fronts consisting of a wrought iron grille with the back of the shaft laid up in white enameled brick.

Anticipated loads for the combined buildings are as follows, daily load between 8:00 a. m. and 6:00 p. m., 575 kw.; evening load between 6:00 p. m. and 10:00 p. m., variable; and the night load between 10:00 p. m. and 8:00 a. m., 190 kw.

That a nice balance has been secured in the engine room can be readily seen when it is understood that for the day load a 750-kw. unit is provided and for the evening load a 250-kw. unit with a spare 750-kw. and 250-kw. unit available for emergencies.

It is to be remembered that all four units have a 25 per cent overload capacity for 3 hr. and 50 per cent overload capacity for 3 min. at full voltage. There is, therefore, a safety factor in plant installation of 3 to 1, for in the event that the two main units were to fail, which is a remote possibility, the two smaller units operating in parallel could develop a maximum output of 525 kw. at their 25 per cent overload capacity. With the elevator service on an automatic dispatch system, together with variable voltage control, there is every reason to believe that the average daily peak load may not exceed 500 kw., which would give the smaller units a 3-hr. run at 25 per cent overload while the larger units were being repaired.

The main switchboard consists of 14 panels; their service being described in the schedule of equipment. One of its most unique features is the main switch which is so constructed that the two outside lines must be pulled before the neutral can be opened and conversely the two outside legs cannot be closed until the neutral is in place.

Location of the coal supply for the boiler room worked out nicely as there was an alley on the west side of the building where coal carts could unload down a series of chutes, spaced midway between column centers, into a coal bunker 79 ft. long by 16 ft. wide and of sufficient depth to hold over 650 T. Coal is taken from the storage bunkers by four bucket conveyors, one conveyor to each boiler. These unload into troughs which shoot the coal into the Dutch ovens above the stokers. Between the two batteries of stokers there is a column which has on each face a control, permitting the fireman to start up the coal conveyors, guide the chute to whatever part of the Dutch oven he desires and upon getting sufficient coal takes two steps to one side to another control which stops the supply. This arrangement so simplified the problem that only one fireman for each shift will be needed.

Ash removal system is a steam jet ash conveyor, the piping for which lies in a trench that is covered with checkered iron plates. It rises at the south wall line of the building and discharges into a cast iron storage tank set up on a structural steel frame at a sufficient height for a truck to back in under and receive a load.

Hand Operated Hoists in Engine Room

The engine room consists of two bays running the full length of the room, each being equipped with 15-T. hand-operated hoists on trolley beams for the purpose of initially expediting erection of this equipment and for the removal at a future date of such parts as may require repairing. This room was extended under the sidewalk 11 ft. to allow doors to be so placed that ready removal or replacement of any material or machinery as became necessary might be taken care of. The fact that the power plant was to serve the old building across the street made it necessary to tunnel under the street. In this work many engineering difficulties had to be overcome, due to interference caused by city and public utility lines and piping.

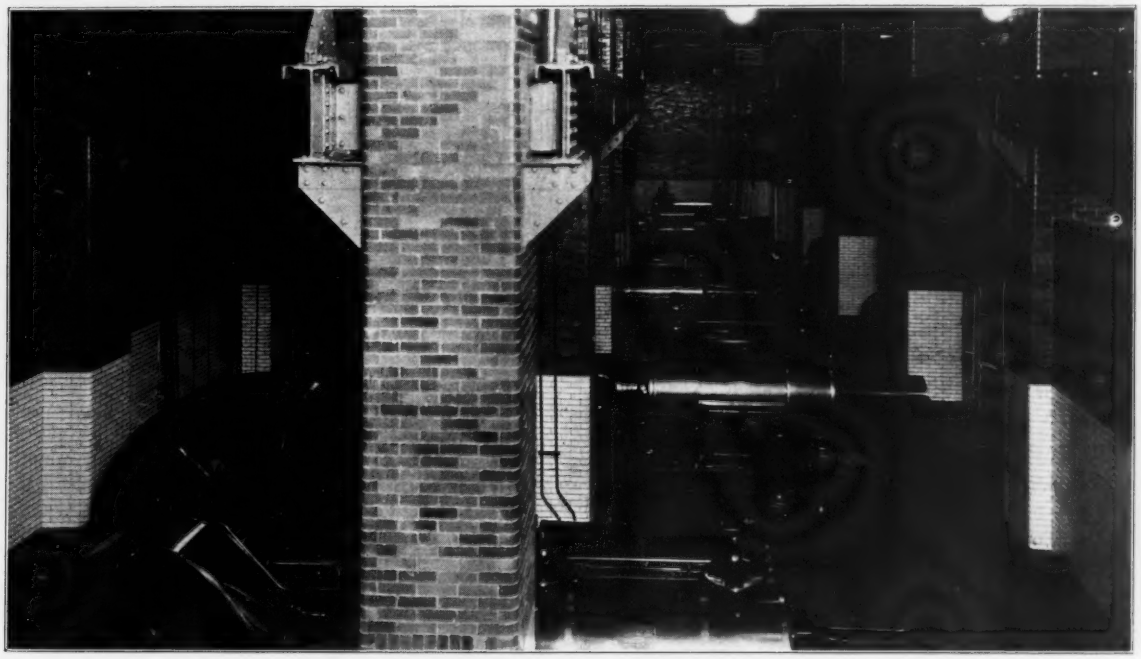


FIG. 1. EACH BAY IN THE ENGINE ROOM IS TRAVERSED BY A HAND OPERATED ELECTRIC CRANE

This engine room is large and special care was taken to see that no auxiliary units were located in it and that no piping was visible. The walls were given a white tile wainscot to a height of 5 ft. 6 in. and above that was laid a salt glazed buff brick to cover all objectionable structural steel work. The ceiling was given a sand finish coat of plaster. The prime movers consist of two 26 by 36 in. Nordberg-Todd high efficiency engines direct connected to two 750-kw., 250-v., Crocker-Wheeler, compound-wound d.c. generators and two 18 by 24-in. Nordberg-Todd high efficiency engines direct connected to two 250-kw. 250-v. Crocker-Wheeler, compound-wound, d.c. generators.

Foundation for each of the generating units is monolithic resting on a sand cushion 6 in. in depth and the surrounding floor was kept 1 in. away from the mass, so that there will be no possibility of vibration being transmitted to the structural steel of the building.

Balancer sets are located immediately in front of the main switchboard. This is a point in design worth stress-

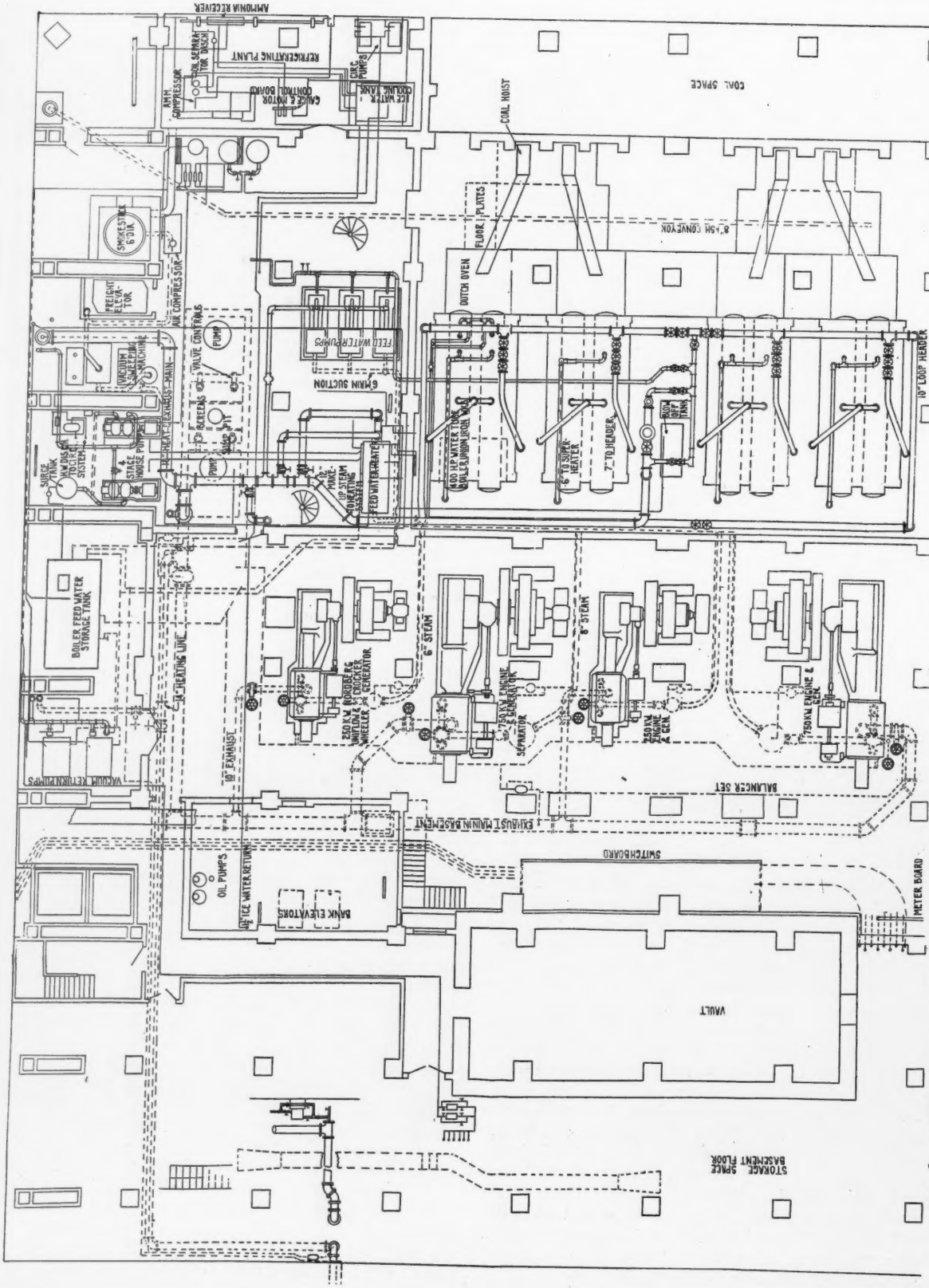


FIG. 2. AUXILIARY EQUIPMENT IS FOR THE MOST PART LOCATED IN BASEMENT ROOM ADJACENT TO THE BOILER AND ENGINE ROOMS

ing, as the operator can without effort operate his board and see exactly what is going on. The gage board is located on the opposite side of the engine room from the switchboard, that is, it is on the wall which forms the division between the boiler and the engine room. The oiling system for the prime movers and generators consists of a gravity feed, filter and return type, with the storage tanks located near the ceiling between the trolley beams of the crane hoists; the filter being located in the pipe space below the engine room floor.

Pipe Leads to Engines Are in Basement

High pressure piping to the engines enters the space beneath the engine room floor. The leads from the main steam header are in trenches which have steel checkered cover plates set in the floor to allow easy access. The steam after leaving the main header goes through an expansion bend into a steam separator, thence into the engine cylinder. After expansion it exhausts into the main exhaust line. About 40 ft. away from the last engine an oil separator has been installed so that all foreign matter may be eliminated before the steam enters the feed water heater and the supply lines to the attic of the new building and the line across the street to the old building.

For the boiler room a space 80 by 53 ft. was provided. The ceiling of this room is suspended and furred with metal lath and plaster. The walls on all sides extend up to the soffits of the tile floors above. Four Union Iron Works boilers were installed. They are of the horizontal drum type, each rated at 400 hp. and designed to operate under a pressure of 235 lb. per sq. in. ga.

Each setting is provided with a superheater designed to increase the temperature of the steam by 125 deg. F. Soot blowers were also installed. It is the intention of the owners to place two boilers in regular operation and hold the remaining two in reserve. The boiler settings, which are of the Dutch-oven type, are constructed of fire brick

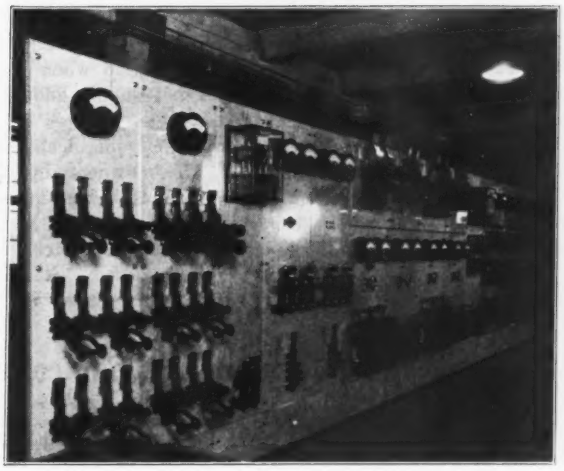


FIG. 4. THIS SWITCHBOARD SERVES BOTH THE NEW AND THE OLD BUILDINGS

and insulating brick and the outside face of the walls is finished off with face brick. No headers extend from either the face or firebrick portions of the walls into the insulating courses. The tie is made by means of metal clips. Stokers are the Murphy type, as manufactured by the Riley Stoker Corp. They are operated under natural draft and are driven by means of steam engines which exhaust into the common low pressure steam system.

The boiler breeching in front of the boilers is oblong in shape and after passing the last unit becomes elliptical, reaching the stack some 40 ft. away in this shape. Both the breeching and the stack have been lined inside and then plastered with a high refractory cement.

Steam piping from the boilers has been designed for the necessary flexibility. From the main header a branch is taken for the kitchen service in the roof garden. It, of

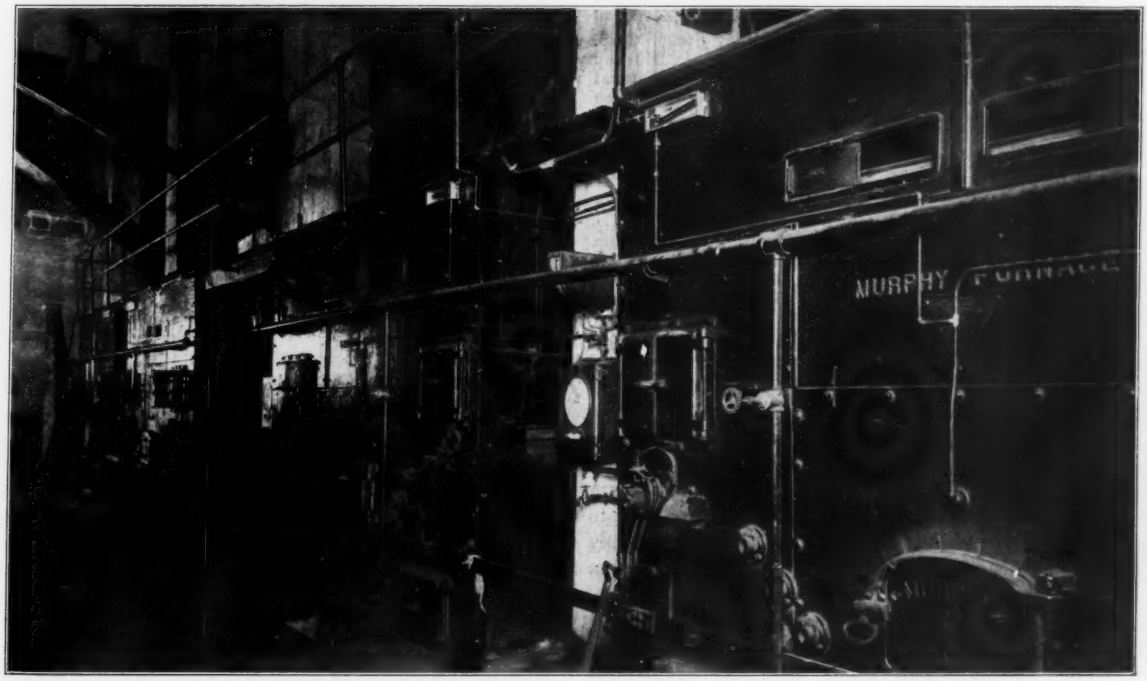


FIG. 3. EACH STOKER HOPPER IS FED BY A COAL CHUTE WHICH TERMINATES AT AN INDIVIDUAL BUCKET CONVEYOR

course, is taken through reducing valves, and a further reduction of this pressure allows steam to enter the low pressure heating system should it be required when the exhaust steam from the engines does not supply enough heating steam.

Feed water is taken direct from the city main and is not at present treated in any way. The owners intend after a preliminary investigation to install suitable equipment to meet local conditions. A Venturi meter has been placed on the cold side of the closed feed water heater.

and a draft indicator showing draft over fire and uptake draft.

Immediately adjacent to the boiler room and entered past an underwriters' fireproof door is the general utility machinery room containing the feed water heater, Venturi meter, sump pumps, house pumps, hot-water pump, vacuum-cleaning machinery, boiler-feed pumps, air compressor and refrigerating machinery. The feed water heater is of the enclosed type with a capacity to heat 54,000 lb. of water per hr. from a temperature of 50 deg.

Principal Mechanical and Electrical Equipment

General
- Location of plant: Cleveland, O.
- Character of service: Heat, light and power
- Elevation above sea level: 600 ft.

Floor space
- Boiler room: 52 ft. by 80 ft.
- Engine room: 52 ft. by 116 ft.
- Auxiliary machinery space: 52 ft. by 70 ft.
- Air washers and heaters: 52 ft. by 70 ft.
- Coal storage: 16 ft. by 79 ft. by 23 ft.

Boilers, make: Union Iron Works
- No. installed: 4
- Type: 2 drum, water tube
- Heating surface, sq. ft., each: 4121
- Pressure, lb. ga: 235
- Settings: Brick
- Firebrick: Harbison-Walker Refractories Co.
- Insulating brick: Armstrong Cork & Insulation Co.

Superheaters, make: Superheater Co.
- Surface, sq. ft., each: 473
- Superheat, deg. F: 125

Soot Blowers: Diamond Power Specialty Corp.

Breeching, material: Steel
- Lining: Johns-Manville, Inc.

Chimney, material: Steel
- Diameter, ft.: 6
- Height, ft.: 325
- Lining, make: Johns-Manville, Inc.
- Above breeching, ft.: 40

Stokers, make: Riley Stoker Corp.
- Type: Murphy
- Draft: Natural
- Setting: Dutch oven
- Grate area, sq. ft. each: 80
- Coal burned: Slack
- Arch: American Arch Co.

Miscellaneous boiler equipment
- Meters: Bailey Meter Co.
- Draft indicators: Defender Automatic Regulator Co.
- Safety valves: Manning, Maxwell & Moore, Inc.
- Water column: Reliance Gauge Column Co.
- Feed water regulator: McDonough Coal Saving Corp.
- Non-return valves: The Lagonda Mfg. Co.

Coal handling, manufacturer: Brown Hoisting Mach'y. Co.
- Type: Bucket
- No. installed: 4
- Drive: Motor

Ash conveyor: Conveyors Corp. of America
- Type: Steam jet
- Storage tank: Cast iron

Steam engines
- Make: Nordberg Mfg. Co.
- No. installed: 2—1125-hp. at 150 r.p.m.; 2— 400-hp. at 200 r.p.m.
- Size: 2—28 by 36 in.; 2—18 by 24 in.
- Steam pressure, lb. ga: 200
- Superheat, deg. F: 100
- Back pressure, lb. ga: 2

Generators, make: Crocker-Wheeler Co.
- No. installed: 2—750 kw.; 2—250 kw.
- Type: d.c.
- Voltage: 250
- Rating: 40 deg.

Main Switchboard, make: Leonard Electric Mfg. Co.
- Panel 1: Elevator load
- Panel 2: Elevator load
- Panel 3: Old building, elevators
- Panel 4: Balancer No. 1
- Panel 5: Balancer No. 2
- Panel 6: Generator No. 1
- Panel 7: Generator No. 2
- Panel 8: Generator No. 3
- Panel 9: Generator No. 4
- Panel 10: Old building, lights
- Panel 11: New building, bank lighting
- Panel 12: Basement and office lighting
- Panel 13: Office floor circuits
- Panel 14: Spare, flood lighting

Balancer Sets: Crocker-Wheeler Co.

Circuit breakers: The Cutter Co.

Watthour meters: General Elec. Co.

Ammeters and voltmeters: Weston Electrical Instrument Co.

Steam separators, make: Cochrane Corp.
- Working pressure, lb.: 300
- Type: Receiver
- Capacity: 2—55 cu. ft.; 2—17 cu. ft.

Oiling system, make: S. F. Bowser & Co.
- Type: Gravity

Overhead cranes, make: Brown Hoisting Machinery Co.
- Operated by: Hand
- Capacity, each, T.: 15

Engine Stop Valves: Strong, Carlisle & Hammond Co.

From the heater, which is supplied with exhaust steam from the non-condensing prime movers, the water goes to the boiler feed pumps and from there a double supply line is installed to prevent the possibility of a shut down.

Boiler Instruments Installed

Each boiler is fitted with a recording steam flow meter, a recording air flow meter, a recording flue gas temperature meter, an integrating steam meter, an integrating flue gas temperature meter, an integrating air flow meter

F. at a maximum pressure of 15 lb. per sq. in. The sump pumps are of the vertical type, motor driven and are fitted with a high water alarm.

House pumps are of the three-stage centrifugal type, direct connected to 220-v. d.c. motors. Each has a capacity of 200 g.p.m. against a static head of 270 ft. They are installed with automatic starting and stopping equipment and owing to the location of the house tanks a pressure of 15 lb. per sq. in. is obtained. The hot water

pump and the vacuum cleaning machinery are also electrically driven.

The boiler feed pumps consist of three 10 by 6 in. duplex bronze fitted, double-acting, outside-packed plunger units. They are adapted to operate under 225 lb. steam pressure and 100 deg. superheat. The piping is so valved that any one of the units may be cut out and used to run a test on any idle boiler, should the boiler inspection bureau require it. The air compressor is a 6 by 6-in. single-cylinder machine operating at 110 lb. pressure, 225 r.p.m., and is driven by a 10 hp., d.c., 220-v. motor connected through intermediate gearing. The compressor starts and stops automatically. The piping from the storage tanks leads to outlets in the engine room where the air will be used to clean the generators, to operate the automatic temperature regulation system for the banking room and roof garden sections and for cleaning the elevator motors and machinery.

Refrigerating machinery consists of a plant of sufficient capacity to cool 200 gal. per hr. for the ice water fountains located throughout the entire building. The compressor is motor driven and the control board for the system is located outside the room proper. This entire equipment with the exception of the control board is located in a separate room, well ventilated, because past experience has demonstrated that the ammonia gas sometimes escapes and permeates an office building.

Two single-stage, centrifugal type pumps are used to circulate the water. They are direct connected to 220-v., d.c. motors by means of flexible couplings. Special thermometers are supplied, one on the city water supply line, showing temperature of supply to the machine and one on each of the supply and return lines of the system, giving inlet and outlet temperatures at the plant.

Immediately above this auxiliary equipment is another level at which is located the hot-water heating tanks, air washing machinery and banking room and miscellaneous fans.

Principal Mechanical and Electrical Equipment, Continued

Boiler Feed Pumps, make	**Platt Iron Wks.**
No. Installed	3
Type and Size	Duplex, 10 by 6 by 12 in.
Fittings	Bronze
Steam pressure, lb. ga.	225
Hot Water Supply Pump	**Power Plant Supply Co.**
No. installed	1
Type	Triplex, single acting
Pressure, lb. ga.	150
Capacity, g.p.m.	40
Drive	Motor
Vacuum Pumps, make	**Nash Engineering Co.**
Capacity, sq. ft. rad.	92,000
Drive	Motor
Control	Automatic, G. E. Co.
Hot Water Circulating Pump	**Triplex, single acting**
Capacity, g.p.m.	40
Drive	Motor
Control	Cutler-Hammer Mfg. Co.
House Pumps, make	**Worthington Pump & Mach. Corp.**
No. installed	2
Capacity	200 g.p.m., 270 ft. head
Type	Centrifugal
Drive	1 motor, 1 turbine
Control	Cutler-Hammer Mfg. Co.
Sump Pumps, make	**Rumsey Pump Co.**
No. installed	2
Type	Vertical
Drive	Motor
Control	General Electric Co.
Feed Water Heater, make	**Swartwout Co.**
No. installed	1
Type	Closed
Capacity, lb. per hr.	54,000
Pressure, lb. ga.	15
Hot Water Heaters, make	**Patterson-Kelley Co.**
No. installed	2
Type	Closed
Capacity, gal. per hr.	1425
Temperature limits, deg. F.	40 to 180
Pressure, lb. ga.	150
Water Meter, make	**Builders Iron Foundry**
Type	Venturi
Size	4 in.
Piping, contractor	**W. G. Cornell Co.**
Pipe manufacturer	National Tube Co. / Reading Iron Co.
Air Compressor, make	**Worthington Pump & Mach. Corp.**
No. installed	1
Air pressure, lb. per sq. in.	100
Drive	Motor, belt
Control	Cutler, Hammer Mfg. Co.
Vacuum Cleaning Plant	**Spencer Turbine Co.**
Drive	Motor
Control	Hand
Air Washing System	**Carrier Engineering Corp.**
Type	Spray
Capacity, cu. ft. per min.	29,000
Drive	Motor
Control	Johnson Service Co.
Air Filters	**Midwest Air Filters, Inc.**
Misc. Ventilating Fans	**Ilg Electric Ventilating Co.**
Refrigerating Equipment	**The Cleveland Ice Machine Co.**
Type	Ammonia
Capacity, gal. per hr.	200
Drive	Motor
Control	Cutler-Hammer Mfg. Co.
Elevators, make	**Kaestner & Hecht Co.**
No. passenger	12
No. freight	2
Type, passenger	Gearless traction
Type, freight	Worm gear tractor
Control passenger	Variable voltage
Passenger, speed, ft. per min.	600
Loading, lb.	2500
Freight, speed, ft. per min.	400
Loading, lb.	4000
Equalizers	Wright Supply Co.
Miscellaneous	
Recording Instruments	Foxboro Co.
Expansion joints	Crane Co.
Expansion valves	Crane Co.
Vacuum return valves	Marsh Valve Co.
Radiators	National Radiator Co.
Radiation control	Johnson Service Co.
Modulation or hand control	American Radiator Co.
Signal system	Lucas Signal & Control Co.
Motor Generator Sets	Westinghouse E. & M. Co.

The elevator system is the first in the city of Cleveland to have a full bank of passenger elevators equipped with Wright equalizers and variable voltage control, together with the feature of self leveling. The equalizing device is a mechanical unit in the nature of three yokes, two of them being fastened by a pin to the ends of the larger one; the whole is then fastened at the bottom to the top of the structural steel framing of the cars and the top is fastened to the elevator cables themselves. Its purpose is to prevent wear on the car cables by taking up the proper tension in each individual cable. Under the old method if one cable stretched more than another it ceased to do its share of useful work.

Variable voltage control which is an adaptation of the old Ward-Leonard system, involves the use of a 230-v., d.c. motor and a motor generator, the generator being separately excited. The control consists of a contactor panel and a car limit switch with resistors. This new system of elevator control was developed by the Westinghouse Elec. & Mfg. Co. and successfully fills the requirements of vertical transportation for acceleration, high speeds, fast car schedules, quietness, and most important of all, economy of power consumption. Some of the special features are that higher car speeds and shorter accelerating periods can be used, landings are made easily and accurately because the rate of acceleration is practically independent of the load and variations of car speeds for the different load conditions are considerably reduced, giving excellent regulation of car speed.

When the car switch handle is moved from the "off" position, it establishes a control circuit that closes one of the generator field contactors on the panel. This results in a small generator field current being built up which causes the car to move at low speed. As the car switch handle is moved away from the "off" position more field resistance is cut out, building up the generated voltage and thereby increasing the car speed. In ordinary service the operator throws the handle from the "off" to the "full speed" position. The generator voltage builds up gradually to 230 v. and the car accelerates smoothly.

It is estimated that on this installation variable voltage control will save about $2400.00 per yr. in power consumption and that the equalizers will triple the life of the cables.

Exhaust Steam Used for Heating

All the engine units exhaust into a 16-in. exhaust line against 2 lb. back pressure. The steam then goes through an oil separator, thence rising where it is piped and valved to the feed water heater and the main exhaust rises to the attic space above the 19th floor of the building. At this level an expansion joint is installed and above the roof level a cast iron exhaust head is installed. At the attic level a tee is installed and from this location the main goes to the center line of each wing of the building where a continuation in a smaller size runs the length of each wing, branching to adjacent column points where supply lines of proper size are taken off the top to the main risers of the building.

Radiators on the typical office floors are equipped with Detroit improved-multipost, modulation valves and thermostatic return valves, which latter will operate against a 2 to 4 lb. steam pressure and 8 in. to 10 in. of vacuum. Each riser is equipped with a Crane expansion sleeve located midway between the basement and the attic, each end being a swing joint. The drips from the various steam risers go to the basement ceiling level and are fitted with a 4-ft. loop, with a gate valve above, all connecting into a riser drain return which terminates at the feed water heater and emergency tank.

The largest ventilating unit in the building is the bank fresh air supply. It consists of a fresh air fan, air washer, settling tank, sprays, strainers, eliminators, pumps and motors, Vento heaters and Johnson Service Co. automatic control. The fresh air fan was manufactured by the Buffalo Forge Co. and is driven by a Reliance motor built for 50 per cent speed reduction and controlled by means of a Cutler-Hammer regulator. The air washer has a capacity of 29,000 cu. ft. per min. and is made of 20-oz. copper. The settling tank is made of 24-oz. copper. The sprays are of brass and strainers and eliminators of 20-mesh copper wire screens and 16-oz. copper, respectively. The pumps are of the double-suction, centrifugal type, direct connected to 230-v. motors which are furnished with Cutler-Hammer starting rheostats.

Vento heaters for the bank fan consist of 4 rows, 50-in. sections, two tiers high with a total of about 2100 sq. ft. of heating surface. The drains connect with the vacuum return pumps which are automatically controlled. Miscellaneous ventilating units are as follows: engine room fresh air fan, 10,000 c.f.m.; coupon booth rooms exhaust fans, 2300 c.f.m.; basement and vault exhaust fans, 6800 c.f.m.; basement and vault fresh air fans and heaters, 13,400 c.f.m.; bank work room, 2700 c.f.m.; attic exhaust fans, 18,600 c.f.m.; engine room exhaust fan, 10,500 c.f.m.; boiler room fan, 9600 c.f.m., and the basement fan, rated at 2000 c.f.m.

For the heating requirements the exhaust steam of the engines is used and whatever other is required is obtained through reducing valves from the high pressure line between the two batteries of boilers.

The estimated saving per year accomplished by the installation of this plant will be in the neighborhood of $21,000.00 net, which makes it an attractive proposition.

According to a report, prepared by E. E. Jones for the United States Department of Interior, seven undeveloped power sites on Roaring Fork of Colorado River, in Colorado, between Snowmass and the mouth of the river, could be made to furnish 31,500 hp. for 90 per cent of the time and 54,000 hp. for 50 per cent of the time. Five additional sites in the river basin have been developed, and the combined capacity of the turbines amounts to 6540 hp., but on account of the closing down of some of the silver mines in the vicinity only 3850 hp. is being used.

Power could be developed at these sites by low diversion dams, constructed of material that could be obtained near the sites and by open conduits having a total length of 29 mi. and an average capacity of 675 second-feet. The total fall in the 29 mi. between Snowmass and the mouth of the river is 1160 ft. The power obtained would amount to 1900 hp. per mile for 50 per cent of the time and 1100 hp. per mile for 90 per cent of the time. The cost of development would seem to be warranted whenever a market is available.

At one of these sites a canal 5 mi. long, having a capacity of 566 second-feet, would be able to carry enough water and to deliver it at such a height above the river as to permit the development of 10,000 hp. for 50 per cent of the time and 6000 hp. for 90 per cent of the time.

Methods of Coal and Ash Handling*

ASH ACCUMULATES AND THEREFORE OFTEN PRESENTS A MORE SERIOUS PROBLEM THAN COAL WHICH DISAPPEARS WHEN USED

IT IS GENERALLY recognized that the storage and handling of coal is one of the important central station problems. Ash handling, which is not always given so much thought, is a more simple problem only to the extent that the ash to be handled is less. Coal disappears whereas ash accumulates and, unless it is disposed of promptly, the plant may be put out of commission. Ash is usually wet when handled, hence it is extremely corrosive. Either wet or dry it is an abrasive, consequently ash handling machinery often requires more attention than any other single class of apparatus. The U. S. Coal Commission made a systematic field investigation among industrials, railroads and public utilities, of methods and costs of storage of soft coal. It was found that in general the larger railroads and the public utilities have a definite policy on storage. It is, briefly, that small reserves must always be maintained and that unusual reserves are only to be accumulated against impending stoppages in supply.

Consumers who have learned to store coal only as a necessary measure of self-protection should undertake it as regular practice. In every year of normal business and industrial conditions, during 6 mos., from April to September, the price of bituminous coal is lower than in the fall and winter. In these months the consumption of coal is lowest. The buyers who wait until fall or winter to place their orders may expect to pay a higher price.

COAL STORAGE AT THE HUDSON AVE. STATION

At the time the Hudson Ave. station was designed it was impossible to secure a lot sufficiently large to provide adequate outside coal storage. It was therefore decided to provide large overhead bunkers in the station and to utilize the coal storage yard of 200,000 T. capacity located at Rossville, Staten Island.

Coal from storage is handled in barges and towed up the harbor from the Staten Island yard. Electric coal towers were selected as being best adapted for the conditions existing at this station. Along the water front a dock 420 ft. long was constructed. On this dock and parallel to the river a coal trestle was built the entire width of the boiler room. Two coal towers of 250 T. per hr. capacity each are run on the tracks of this elevated structure. Coal is raised by means of a grab bucket and dumped into an overhead hopper supplying a duplex single-roll crusher and thence into a storage hopper. From this hopper the coal is distributed to the overhead bunkers by means of an automatic electric coal car system.

Each structural steel tower is 83 ft. high above the top of the coal trestle and is provided with a 50-ft. horizontal boom extending out over the vessel and a receiving hopper built into the face of the framework. An equalizing hopper is provided directly below the crusher, which terminates in two openings above the trackway of the distributing car system. The openings are provided with gates of the duplex undercut type.

The Adirondack Power and Light Corp. has recently completed a system for the seasonal storage of coal at its Amsterdam steam station. This system makes use of the drag line scraper in a rather novel manner. The station uses anthracite screenings, generally known as No. 3 buckwheat. Coal from the west must be delivered at the east end of the property or else carried on to the next junction point and returned on the west bound track. For the same reason coal from the east must be delivered at the west end of the property. It was therefore necessary to provide both an easterly and westerly connection with the railroad. The logical solution was a series of tracks running east and west on the station property.

PROVISION MADE FOR UNLOADING FROZEN COAL

Because of the frequent long periods of severe winter weather, coal delivered in the winter is generally frozen and unloaded with great difficulty. It was consequently decided to provide storage space for substantially a winter's demand. It was also necessary to provide for unloading frozen coal. The use of an elevated trestle appeared to be the most satisfactory means of unloading frozen cars.

Coal-handling system of the extension consists of a skip hoist taking coal from the drag hopper and delivering it to the bunker between the old and new sections. The coal is delivered to the boilers by a 5-T. weigh larry. The drag line scraper is arranged so that coal can be dragged from beneath the concrete trestle to the coal pit of the skip hoist. A back post is installed so that coal can be drawn from the trestle, or any part of the lot, to a point under the gantry crane which is kept in a fixed position. This crane, therefore, becomes an auxiliary coal system to be used in case of failure of the skip hoist, or as a secondary means in case large quantities of coal must be handled. Another feature of interest is the substitution of a tail block car on a circular track in place of a line of tail blocks.

At the Warrior steam plant, the principal steam generating station of the Alabama Power Co. there are eighteen 1200-hp. boilers with ash hoppers arranged to dump into narrow gage cars on the ash pit floor. The cars are handled by hand from the short tracks extending under the hoppers out to the main track across the end of the ash pit room. From this main track, the cars are handled by electric locomotives to the ash fills, where they are dumped on the side of the track. Fortunately for the ash handling program, this is so situated that there is a great deal of surrounding territory which can be advantageously filled in with ash. A great portion of the coal storage area has been reclaimed from low or submerged ground in this manner. A temporary ash trestle is built out some distance over the area to be filled in and the ash is dumped at the end of this trestle close to the plant; the ash being thoroughly cooled by sprinkling before leaving the plant, little hazard is offered of burning the trestle. As the dumping progresses and the cinders settle around the trestle foundation, the trestle becomes more rigid and it is safe to move further on with the dumping.

Coal is brought to the East Peoria power plant of the Illinois Electric Power Co. in standard coal cars and dumped or unloaded with a locomotive crane into three 16 ft. by 16 ft. concrete track hoppers, so constructed that a car dumper may be installed later. An apron conveyor feeds the coal to a 200-T. American ring crusher

*Abstracted from Prime Movers Committee Report, N.E.L.A.

which may be bypassed. From here the coal is carried on a magnetic belt to a V-bucket elevator of 75-T. capacity per hour. The buckets are of heavy malleable iron construction, 20 in. by 30 in. and 10 in. deep. This conveyor discharges by gravity onto a flight conveyor of heavy construction. The coal elevator is at the end of the present building, which houses two 20,000-kw. turbines. The raw coal bunkers, located in the space opposite the aisle between the boilers, alternate with pulverized coal bunkers which are directly in front of the boilers.

Each boiler is provided with two ash hoppers, whose sides have a slope of 75 deg. to the horizontal. These hoppers are of concrete, lined with insulating brick covered with fire brick and provided with hydraulically operated ash gates. The ash discharges into a brick lined concrete sluice having a slope of ¼ in. per foot. A 1000-g.p.m. pump supplies the sluicing water and a manganese steel lined pump of 1600-g.p.m capacity pumps the ash to the lowlands around the plant.

Ample equipment has been provided to meet the coal storage and handling problems for both local and distant coal supplies at the Philo station of the Ohio Power Co. Coal may be brought to the plant by railroad cars, barges, or in the future, by aerial tramway directly from the mines across the river. A portion of the old canal between existing locks has been widened and deepened for a submerged coal storage which will hold approximately 300,000 T. Water may be admitted or drained from this storage by control valves at the locks. A dry storage of 100,000-T. capacity has been developed alongside of the submerged storage. Ash passes into continuous ash hoppers below each boiler and is fed through clinker grinders into a hydraulic ash conveyor, the ash being discharged into a pit from which it is pumped by large dredge pumps to a distance of 1500 to 1800 ft.

Ash disposal at the Riverside plant of the Northern States Power Co. is exceedingly difficult during the winter months because of the extreme cold weather and heavy snowfalls which completely tie up both rail and truck traffic. This has necessitated the installation of rather large ash storage hoppers so that two or three days' supply of ash may be conveniently handled during these periods of severe weather conditions. Steam heat is provided so that the refuse in storage will not freeze and will flow easily when trucks are available.

Use Made of Locomotive Cranes

It is the practice at the larger plants of this company to use a 20 or 25-T. locomotive crane equipped with a 50-ft. boom and a bucket having a capacity of 1½ or 1¾ cu. yd. At the smallest plant there has been installed a 20-T. caterpillar type locomotive crane, with a 38-ft. boom and a bucket of ¾-cu. yd. capacity. This crane was originally used on a construction job.

In the larger plants this company is using standard gage Clark side-dump cars for the disposal of ash. This car is used for heavy railway construction work and has the advantage of dumping the waste material at the maximum distance from the track center. Too much emphasis cannot be placed upon the proper quenching of ash, in order to reduce car maintenance.

In order to eliminate spontaneous combustion of coal in storage, without the disadvantage of submerged storage, the Philadelphia Electric Co. has devised a unique and effective method of storing coal. It is necessary to keep a large amount of coal in storage, principally as an insurance against strikes. At present over 225,000 T. of bituminous coal are in storage at several points of the system. This coal has been in storage over 2 yr. and has given no trouble. The ground is prepared by covering it with ash or dry earth and then rolling it hard. Over this the base of the coal pile is started by spreading a layer of coal, approximately 2 ft. deep, over a width of from 90 to 100 ft., and 1000 or even 2000 ft. in length, depending on the length of the property on which the coal is to be stored. This coal is handled by a locomotive crane. A caterpillar tractor weighing approximately 2 T. then grades this first layer of coal with a drag and after the coal has been leveled a roller is drawn over the pile, thus packing the coal. The second layer is then started in precisely the same manner and after it is packed, the third layer, and so on up until the top of the pile is only as wide as the tractor and the roller.

Loose Coal Is Placed on Top

During the time that this pile is being built there is a certain amount of loose coal that will roll down the sides of the pile. If left there it will undoubtedly cause trouble in the form of small surface fires. To eliminate this, the operator on the crane trims the sides of the pile at the ground level the width of his bucket after the pile has been completed and in this manner gathers up the loose material and places it on the top, thus forming the crown of the pile. The pile has now been thoroughly packed from top to bottom. The interesting feature of this is that coal which would weigh 45 and 50 lb. per cu. ft. if piled normally without packing, now weighs 65 lb. per cu. ft. The surface of these piles is so closely packed that it readily sheds water and in all probability the circulation of air is entirely eliminated. Temperatures of this coal have been taken at least every six weeks from the time that the coal was placed in storage.

Temperatures clearly indicate that there is a considerable lag of temperature within the coal pile compared with the external air, showing that there is no free circulation of air in the pile but rather that the air is excluded and the temperature variation is governed more or less by contact convection. The various coal piles have been divided into sections and numbered, the records showing the analyses of the coal in the various piles as it was stored. This coal will be analyzed as it is removed from storage and it is hoped to obtain some definite figures on the losses which may be expected. The coal storage piles average from 25 to 30 ft. in height. It has been found necessary to crush the coal to insure success with this method.

The United States Civil Service Commission announces that competitive examinations are open for assistant chief accountant-engineer, $3800, senior accountant, $3300, and accountant, $3000, to fill vacancies in the Department of Agriculture for assignment to duty with the Federal Power Commission. All applicants for these positions must be qualified in public utility accounting as applied to electric light and power utilities. Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C.

Silicon steel, under low magnetizing forces, is far more magnetic than the best Swedish iron. Furthermore, it does not suffer from "ageing"; that is, its good magnetic properties do not deteriorate, as happens with the iron.

Removing Water From Steam Mains

DAMAGE IS OFTEN CAUSED BY SLUGS OF WATER PASSING THROUGH STEAM MAINS TO THE PRIME MOVER. BY C. C. HERMANN

IN THE SATURATED steam plant priming is a common fault and trouble. Slugs of water carried over with the steam not infrequently cause great damage to prime movers. An engineer of a laundry told me about his trouble in this regard just the other day. He laid the priming to the fact that his softener did not remove the minerals in solution in the water. These minerals, he claimed, caused an extremely thin and light scale in the boiler and considerable foam. The boiler would prime easily and unless he would throttle the engine slightly the boiler would prime heavily. I am not passing judgment on his diagnosis of the trouble, however, in general, priming is due to forcing the boilers beyond their rating. The point I want to bring out here is the great danger to steam engines due to water in the steam lines.

Some engineers point to the backward slope they have provided to take care of the water. All we can say to these gentlemen is that the slope of 3 or 4 in. is no assurance against water being carried over and into the engine cylinder.

The resistance caused by the flow of steam may be sufficient to bank the water up until it fills the pipe. It

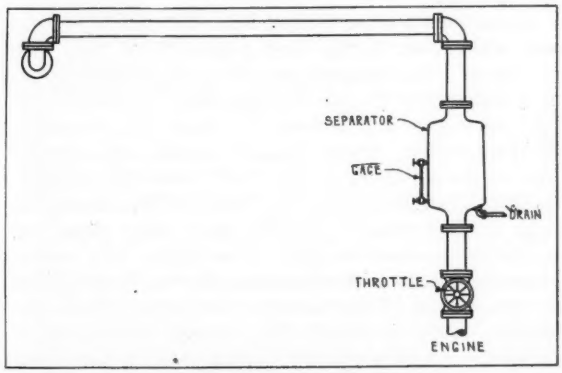


FIG. 1. IN THIS CONSTRUCTION THE SEPARATOR IS RELIED UPON TO REMOVE THE WATER

would be just as reasonable to believe that the wind will not make huge waves on the ocean as to believe that high velocity steam will not bank up the water in the pipe. With this in mind it would be far more reasonable to place the slope of the pipe away from the boiler and let the steam carry the water out and beyond the engine take-off. We shall speak of this point again.

Water segregates in the steam mains, due not only to priming of the boiler but also to condensation. Uncovered steam mains especially cause considerable condensation. In the case of superheated steam there may occur a considerable heat loss before the steam temperature is down where condensation will take place, and this is why prime movers show such increased efficiency with superheated steam. With saturated steam the only thing that can be done is to reduce the length of the transmitting mains to the absolute minimum and then cover them efficiently. The main object is to eliminate as far as possible the condensation in the pipes and then provide means for removing what condensation does occur at the proper point and in the most advantageous manner.

Danger of water reaching the steam engine cylinder exists in practically every installation. In some installations, however, this danger has been more directly combated than in others; in fact, I have seen installations where apparently the question had never really been considered. The only reason trouble had not been experienced was probably due to the further inefficiency existing in the installations consisting in a large factor of over capacity both in generating units and prime movers. That water collects in the header there is no doubt; however,

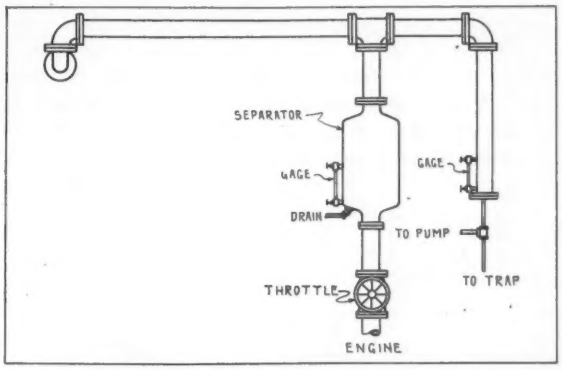


FIG. 2. DROP LEG IS OFTEN EFFECTIVELY USED FOR THE REMOVAL OF WATER FROM STEAM LINES

the fact that the engine operates at a light load continually saves the day. A sudden overload on the engine would probably result in a badly damaged piece of equipment.

Not long ago I visited a power plant and discussed this problem with the engineer. He pointed to his steam separator with the remark, "That is the way we solved the problem."

"But, my friend," I remarked, "the gage glass is gone."

That is the trouble with most separators. The gage glass becomes broken and replacement is put off for this and the other reason. The gage glass on the separator is of equal importance with the water glass on the boiler. The engineer can then see the water level in the separator. The drain may stop from some cause or other and the separator be rendered ineffective.

TWO TYPES OF HEADER CONSTRUCTION

Steam header construction may be considered from two specific angles of construction, namely: First, dead end construction. Second, water leg construction.

Figure 1 illustrates the dead end construction ordinarily encountered in the engine room. Obviously the steam separator is relied upon to remove all the water and if properly installed and of the correct capacity it will do this work effectively unless extraordinary inattention exists. Any water carried in the steam line sooner or later finds its way to the separator. If the drain is kept open this water will be effectively bypassed to the return line. A water gage glass is provided and the thing to be remembered with regard to valves at either end of the gage glass is that they are placed there to enable the repair of the gage without the necessity of closing down the engine.

As soon as a new glass has been installed these valves are to be opened again.

Figure 2 illustrates the water leg construction. The header is continued beyond the engine take-off and terminates in a water leg. The water leg is provided with a water gage which enables the engineer to see the condition at this point. The end is closed with a blank flange drilled and tapped for a smaller pipe fitting. From this connection a pipe is taken off to the boiler feed pump and another lead to a steam trap. In case the trap fails to work, the boiler feed pump will take care of the water. This latter would not do for continuous operation and only serves as an emergency outlet.

The engine is equipped with a steam separator. This separator is provided with a drain and gage glass. This design is more or less automatic and does not depend upon the care of the attendant to the same extent as it would should the boiler feed pump connection be eliminated. The drains should be controlled by steam traps. A valve constitutes an unsatisfactory method for draining separators or drop legs. The valve depends upon the human element and, being human, the engineer may

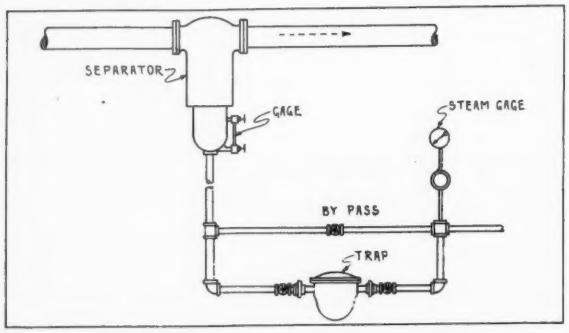


FIG. 3. STEAM GAGE MAY BE USED TO INDICATE WHEN WATER IS FLOWING FROM A TRAP

forget about it until it is too late. The fact that the attendant had forgotten to manipulate the valve of such a drain would not be as much of a disparagement as the inexperience of the designer who specified a valve in the drain.

Water legs will not remove entrained water, for no baffling arrangement or centrifugal action is provided that would tend to remove the water from the steam. If this is desired, it would be necessary to install another separator in the leg. Where the boiler capacity is large and two or three engines are operated from the one header, this may be advisable. In fact, it is advisable wherever the added expense of the separator would prove an advantage for the boiler feed pump. The water leg will, however, remove all condensation that comes over with the steam. Its use is recommended at all times and particularly where the water is taken care of at the consumption end of the header.

Exhaust Lines Must Not Be Forgotten

If water removal from the steam lines is important and every engineer will agree that this is the case, then the efficient removal of water from the exhaust line is of greater importance. The exhaust carries out considerable condensation and water forms rapidly from the low pressure steam. This water must be removed as rapidly as collected. Before starting the prime mover the water must be removed from the cylinder and exhaust line. In case the engine operates condensing, the condenser should, of course, be started first and the engine started non-condensing, exhausting to the atmosphere until full speed is reached. The drains are left wide open until full load is reached and the engine has been previously heated up at both ends.

Drainage of the exhaust line should receive attention. Its size should in all cases be such as will remove the water with the least possible delay in starting the engine. The same thing may be said about the valve method of draining the exhaust line as previously stated with regard to the steam line drain. If the water in the exhaust pipe rises to the engine level it will of course flow into the cylinder. Starting the engine in this condition is dangerous indeed.

In one power plant I visited, the engineer connected the drain to a trap. The discharge of the trap was into a funnel. The advantage was that he could see whether or not the trap was working without disconnecting it. The funnel allowed the water to flow to the return. A check valve placed in the pipe near the connection with the return line was opened by the weight of the water column below the funnel. The object of the valve was to prevent flow of steam should a blowing trap result somewhere along the line.

Drains should never connect into other piping or into a sewer where there is the least possibility of their being waterlogged. For example, a sewer may become plugged up, causing water to rise over the end of the drain pipe. When the engine is shut down this water may be pumped into the cylinder. Avoid, if at all possible, any return of water to the cylinders by good and sufficient drain to a dry spot. Pumping water into the cylinder through the drains can be avoided by keeping these valves closed until the engine has been stopped. The engine will continue to operate for a number of strokes after the steam throttle has been closed. This converts the engine into a good pump.

Traps Should Be in Good Working Order

Steam traps on the average are reliable, however, when it comes to the removal of water from the steam lines feeding the engine it is of vital importance to know that a trap is working. A pet-cock placed in the trap on the water side or in the return will tell the story if the attendant manipulates the valve occasionally. This again depends upon the opening and closing of the valve and will, in most cases, be slighted. In one plant I noticed a steam gage on the return line just over the trap. Not having seen this sort of arrangement, I inquired and found that the gage had been placed there in order to show whether or not the trap was working. When the trap was discharging water the gage will show a pressure in proportion to the velocity of the water ejected by the trap. If there is no water flowing, the trap is not working and the gage does not show a pressure. The arrangement was as shown in Fig. 3.

This illustration also shows another method of installing the steam separator when the drop leg is eliminated. The trap is provided with a bypass for emergency use in case the trap fails. This bypass is important, as it will enable repairs to be made without closing down the prime mover.

Performance at the Lakeside Station*

ACTUAL OPERATING HEAT CONSUMPTION OF THE STATION IS WITHIN 5 PER CENT OF THEORETICAL STANDARD. BY M. K. DREWRY

COMPARISON OF theoretical possibilities and actual station performance has been made at Lakeside Station during a given period of best economy, October 10 to November 10, 1924, by the following means: (1) Computing plant "efficiency ratio" when the station was most economically loaded, estimating 2 per cent radiation and miscellaneous losses. (2) Finding losses attendant with actual operation, due to uneconomical loading of turbines and boilers and to starting and banking, using actual operating data. (3) Calculating the theoretical cycle of efficiency with which a perfect station would have worked and multiplying this cycle efficiency by the efficiency ratio of the actual station. (4) Equating actual and calculated heat consumptions to check allowances made in the calculations for radiation and miscellaneous losses.

TABLE I. COMPARISON OF THEORETICAL POSSIBILITIES AND ACTUAL PERFORMANCE

	Per cent
Most Economical Loading	
1 Boiler efficiency (computed from losses)	91.6
2 Turbo-generator efficiency ratio (from tests)	76.2
3 Consumption of auxiliaries	
Electrical auxiliaries (from meters)	4.25
Steam (credit given for heat return to condensate; taken from operating data)	1.84
4 Coal drying (from operating data)	0.25
5 Radiation and miscellaneous losses (by difference to equalize items 14 and 15)	2.2
6 Efficiency ratio,[1] most economical loading	64.0
Losses Attendant with Actual Operation (Calculated from Operating Data)	
7 Boiler room	
Uneconomical loading of boilers	0.25
Banking and starting cold boilers	1.98
8 Turbine room	
Uneconomical loading	1.75
Starting	0.26
9 Unusual operations	
Entire plant	0.22
10 Total operating losses	4.49
11 Calculated efficiency ratio, average operating conditions	61.1
12 Theoretical cycle efficiency (Marks and Davis tables)	35.4
13 Calculated plant thermal efficiency	21.6
	B.t.u. per kw-hr.
14 Corresponding calculated heat consumption	15,800
15 Actual plant heat consumption	15,800

[1] A measure of equipment efficiency. Actual boilers, turbines, and auxiliaries have a combined efficiency of 64 per cent that of perfect equipment.

That the actual operating heat consumption of the station is within 5 per cent of that theoretical standard which considers all equipment operating most economically, is shown by Table I. In terms recently introduced, its "operating efficiency ratio" is approximately 95 per cent. Of the 5 per cent difference, about one-quarter of 1 per cent can be attributed to uneconomical boiler loading, 2 per cent to banking and starting cold boilers, 2 per cent to uneconomical loading and starting of turbines and the remainder to unusual operations and miscellaneous losses.

Continuous measurement of the most significant measurable losses in boiler operation allows boiler efficiencies to be accurately deduced by totalizing these comparatively small losses instead of equating the large inputs and outputs as done in complete boiler testing. Reliance is placed upon the method since it indicates the same efficiencies which extensive monthly calculations have shown must be realized in actual operation.

Of the losses, that of combustible flue gases is the only one not measured. No attempts to learn the percentage of combustible in the flue gases have as yet been successful, for the particles of ash have been found so extremely fine that no convenient filter will remove proportional quantities of ash and coal. Loss due to unconsumed hydrocarbons cannot be detected in the furnaces until excess air is decreased below 15 per cent, and then CO appears in small quantities.

Radiation losses are undoubtedly small. Furnace-casing temperatures average about 110 deg. F., and practically all heat losses contribute, with the supply of heat in the generator cooling air, to maintain the combustion-air temperature at 100 deg. F. The coolest daily average combustion-air temperature recorded the past winter was 80 deg. F. Turbo-generator efficiency is a weighted value derived from test results by averaging the Rankine-cycle efficiency ratio of the four units installed and operated during the time considered. The efficiency ratio recorded includes generator losses and excitation energy. Steam consumption of all electrical auxiliaries is measured with integrating meters, and that of steam auxiliaries is obtained by recording the time operated and multiplying by factors learned by test of each unit. Credit for heat returned to the condensate by exhaust steam from the auxiliaries has been allowed.

TABLE II. DIVISION OF ENERGY TO AUXILIARIES

A—Electrical Auxiliaries	Per cent
1 Station lighting	0.1
2 Coal handling:	
Car dumper	0.0006
Magnetic pulley	0.006
Crushers	0.02
3 Preparation house:	
Conveying green coal	0.003
Pulverizing	1.08
Conveying pulverized coal	0.025
Total	1.110
4 Boiler room:[1]	
Induced-draft fans	0.50
Coal-feeder motors	0.06
Primary air fans	0.25
Boiler-feed pumps	0.62
Air compressor, machine shop, etc.	0.25
Total	1.65
5 Turbine room:	
Circulating pumps	0.88
Hotwell pumps	0.29
Air removal (on one unit)	0.17
House service and miscellaneous	0.03
Total	1.37
Total energy for electrical auxiliaries	4.25
B—Steam-Driven Auxiliaries	
1 Boiler room:	
Exhaust heat reclaimed:	
Boiler-feed pumps	1.24
Induced-draft fans (one boiler)	0.02
House service pump	0.01
Exhaust lost:	
Steam jets on burners	0.01
Boiler soot blowers	0.2
Economizer soot blowers	0.43
Superheater soot blowers	0.31
Ash conveyors	0.4
2 Turbine room:	
Steam-jet air pumps	0.36

[1] Estimated from tests.

Chief of the unreclaimed radiation losses is the 25-deg. drop in superheated steam temperature from boiler room to turbine room. Blow-down losses are slight, 6 B.t.u. per kw-hr., the character of Lake Michigan water being such that the few dissolved solids settle out at the blowoff pads and that the concentration of the boiler water is caused to remain continuously low, in fact less than 0.1 deg. Be. Another source of loss is that of steam leakage through radiant superheater elements which were then in the development stage. An accurate estimate of this loss based

* Abstracted from paper presented at spring meeting of A.S.M.E., Milwaukee, Wis.

TABLE III. MISCELLANEOUS CHARGES AGAINST OPERATION

	Pounds of steam
Testing emergency governors on Nos. 1 and 3 turbines	110,000
Testing emergency governors on Nos. 1, 2, 3, and 4 circulating pumps	20,200
Cutting in Nos. 2 and 3 headers	12,000
Siphons on smoke washer	62,275
Setting safety valves, No. 2 boiler room	6,630
Equivalent steam for refuse taken from mill rings	84,219
Equivalent steam for weight of iron taken from magnetic pulley	36,805
Equivalent steam for coal taken for drying out new furnaces under construction	158,674
Equivalent steam for boiler fillings and special blow-downs	452,955
Total	943,758
Percentage of plant output	0.22

upon the quantity of make-up places it at 0.9 per cent, for the theoretical make-up required is 2.2 per cent and the actual average was 3.1 per cent. Pop-off losses must obviously be small since they are included in the 2.2 per cent radiation and miscellaneous losses.

Tests have indicated that 2½ per cent of normal coal feed (at 215 per cent of rating) is necessary to bank a boiler and maintain its pressure. Operating data reduce the amount below 2 per cent because the proportion of banked and inactive hours to active hours is less than unity.

The question of load factor influencing economy enters in this connection. That the ratio of average load to maximum demand load is of smaller consequence in the economy of Lakeside than is the matter of turbine loading is proved by a short calculation. The comparatively greater sustained economy with which pulverized-fuel boilers can carry widely variable loads than steam turbines can carry given loads explains why load factor has not as important an influence upon economy as has the question of turbine loading.

Actual plant economy is obtained twice monthly, and the one recorded in item 15 of Table I is an average of two biweekly accountings. The plant heat consumption for the first two weeks considered, October 10 to 26, 1924, was 15,869 B.t.u. per kw-hr., and that for the remainder of the monthly period was 15,721, making an average of 15,795 B.t.u. per kw-hr.

TABLE IV. OPERATING DATA AT THE LAKESIDE STATION

Plant	Oct. 10 to Nov. 10	Dec.	Jan.	Feb.	March
1 Daily coal consumption, tons	867	915	934	825	966
2 Daily output, million kw-hr	1.423	1.528	1.557	1.542	1.629
3 Make-up water, per cent	3.12	3.80	3.19	2.85	2.51
Boiler Room					
4 Rating	213	227	228	228	225
5 Boiler hours, daily	141.7	136	138.5	136.94	142.4
6 Banked hours, daily	17	18 1	19.5	19.3	28.63
7 Combustion-air temperature, deg. fahr.	99	82	84	84	83
8 CO_2, per cent	14.7	14.8	14.8	14.8	14.7
9 Steam temperature leaving superheater, deg. fahr.	702	687	710	721	717
Gas Temperatures, Deg. Fahr.					
10 Economizer inlet	564	572	573	574	568
11 Economizer outlet	232	237	243	244	248
12 Drop in temperature	332	335	330	330	320
Feedwater Temperatures, Deg. Fahr.					
13 Economizer outlet	251	248	254	258	260
14 Economizer inlet	119	121	133	137	137
15 Rise in temperature	132	127	121	121	123
Turbine Room					
Temperatures, Deg. Fahr.					
16 Throttle, Nos. 1 and 2 units	671	647	640	...	619
17 Throttle, No. 3 unit	682	660	677	683	684
18 Throttle, No. 4 unit	689	658	688	701	695
19 Throttle, No. 5 unit	....	673	693	702	701
20 Condenser hotwell	73	63	64	63.2	61.8
21 Circulating-water outlet	67	53	56	55.9	54.4
22 Circulating-water inlet	53	38	41	41.1	40.7
23 Circulating-water rise	14	15	15	14.8	13.7
Pressures, Lb. Gage and In. Hg Abs.					
24 Throttle, all turbines	288	286	289	291	293
25 Exhaust Nos. 1 and 2 units	0.91	0.63	0.56	..	0.56
26 Exhaust Nos. 3 and 4 units	0.94	0.78	0.76	0.76	0.74
Preparation House					
27 Per cent moisture, drier inlet	4.54	5.58	6.75	7.64	7.18
28 Per cent moisture, drier outlet	2.82	2.52	2.48	2.85	2.72
29 Per cent moisture removed	1.72	3.06	4.27	4.79	4.46
30 Tons coal used in drier daily	1.84	6.08	6.96	7.56	8.23
31 Lb. coal used per per cent moisture removed per ton dried	2.90	4.72	3.53	3.41	3.82

Duplicate Coal Analysis Must Check

Sampling is done in the crusher house as the crushed coal leaves the hammer mill and starts upward on the conveyor belt to the preparation house. When coal is being conveyed, 25 samples of the thoroughly mixed coal are taken from the belt, each at 10-min. intervals, until the accumulated pile of 35 lb. represents 500 T. of coal. This sample coal, with the exception of about 5 lb. for moisture determination, is then crushed finely in a test crusher which rejects nine-tenths of the prepared sample and retains one-tenth. The average fineness to which coal was pulverized during the October 10 to November 10 period was as follows:

Mesh	200	100	50	40	30	20
Per cent through	64	81	96	99.2	99.8	100

The average moisture content at the boiler bins was 1.77, showing that in being pulverized about 1 per cent of moisture was removed.

To encourage economy in the use of coal, steam and electricity, all operators at the station are paid a percentage of the saving they effect in excess of a predetermined standard. Obviously, to be effective the bonus system needs to be based upon accurate data, therefore, only monthly economy figures are used. Calculation of the standard station efficiency is made each month and all operators are paid 45 per cent of the actual coal saved above the standard set. The bonus paid has varied from 8 to 15 per cent of the stipulated wage since the bonus system has been inaugurated.

Keeping constant watch of plant equipment and data suggests means of decreasing losses. Better performance of one unit of equipment than of other similar units prompts improvement of the poorer units, and thus best possible results are obtained from every unit.

No standards of air leakage into condensers were determined until test equipment showed one unit leaking less than 5 cu. ft. per min., the equivalent of the leakage through a ⅛-in. orifice. It was reasoned that the other 30,000-kw. units could be made equally tight and at present the air leakage of all units averages about 5 cu. ft. per min. Turbine loading, unlike boiler loading, is given careful attention. Except during peak- and low-load periods, the 30,000-kw. units are kept accurately at their most economical loads by making the overload valve gear inactive. In such cases the pressure drop through the primary valve is reduced to 7 lb., and is maintained at that point at all times irrespective of slight changes in frequency.

Maintenance of maximum boiler and economizer air leakage at or below 1.5 per cent CO_2 decrease in the gases has been set as a standard after weekly observation of this source of loss. This 1.5 per cent air leakage includes infiltration through the economizer bottom.

Maintenance Determines Boiler Ratings

Because of the flatness of the pulverized-fuel boiler-efficiency curve obtained in actual operation and of the small banking losses, an exhaustive study of various loading combinations has shown little difference in the resulting economy. Maintenance and other considerations determine ratings of individual boilers rather than does economy.

Table IV gives operating data collected during the period considered and the months following. Averages were

taken of operation during the five full working days of each week and when boilers were operating at 200 per cent rating or over.

In conclusion, it may be stated that a modern power station may be so designed and operated that its ultimate efficiency will be within 5 per cent of the combined efficiency of its component equipment working at most economical load. The combination of boilers, turbines, and auxiliaries, allowing for radiation and miscellaneous losses, may work at an efficiency ratio of 64 per cent in a pulverized-fuel station. This percentage multiplied by the thermal efficiency of the cycle employed and by 95 per cent operating-efficiency ratio should give the approximately ultimate overall efficiency of any pulverized-fuel station using standard equipment.

Totalizing the losses of energy in the Lakeside station, all of which except those of radiation and a few minor ones are measured and applying the total to the theoretical efficiency of the cycle employed, shows that a performance of 15,800 B.t.u. per kw-hr. is reasonable. Decrease in boiler-unit efficiency below that at most economical rating due to operation throughout the range of loads found in actual practice may aggregate less than one-half of one per cent in the case of a pulverized-fuel installation. Banking losses of a pulverized-fuel station operating at 65 per cent load factor may be limited to 2 per cent.

Energy cost of pulverizing coal was 1.1 per cent, and that of conveying and pumping it before and after pulverization was almost negligible. Drying the coal before reaching the furnaces consumed 0.25 per cent of the total coal flow. Assuming 30 per cent drier efficiency and allowing for the heat necessary to evaporate this moisture in the furnace if not previously dried, the net energy cost of the coal-drying process was 0.16 per cent.

Of the losses in the process of combustion in the furnace and of heat absorption in the boiler, superheater, and economizer, 45 per cent are unavoidable because of hydrogen and moisture in the coal and air. Allowing for these unavoidable losses, the boiler unit may be considered to have an efficiency of 95.4 per cent.

Load factor in the case of a pulverized-fuel station may have less influence upon coal economy than has the question of turbine loading. The employment of a bonus system, besides encouraging economy, demands the keeping of accurate and comprehensive records, which aid in bettering the performance of plant equipment.

Selecting the Right Size of Air Pump

IT MAY BE ASSUMED THAT THE WEIGHT OF AIR TO BE REMOVED IS PROPORTIONAL TO THE WEIGHT OF STEAM. BY H. E. CARLETON*

CAPACITY of an air pump is usually expressed in cu. ft. (atmospheric condition) of dry air per min. This value is useful in comparing air pumps of similar characteristics but it does not state the true capacity of the pump when handling vapor-saturated air under condenser conditions. As shown below, however, the capacity of the steam jet air pump when handling saturated air at any vacuum can easily be calculated from the dry air capacity. At "dead end" the steam jet air pump will reduce the pressure of dry air to about 0.25 in. mercury absolute; but if pure water vapor unmixed with air be admitted to the suction of a steam jet air pump, the pressure will be reduced to a point corresponding to the temperature of the water vapor. If air be admitted to the suction of the air pump, the vacuum will be decreased by an amount depending upon the weight of dry air admitted, whether the air pump is also handling water vapor or not. That is, if the partial pressure of the water vapor at the air pump suction remains the same a given quantity of air will decrease the vacuum by the same amount no matter whether the temperature of the water vapor is 80 or 110 deg.

Thus, if it is assumed that 26 cu. ft. (normal density) of dry air leaks into the condenser in one minute, and that it must be removed saturated with water vapor at 90 deg. F., the vacuum which a certain size steam jet air pump will produce can be determined as follows: From the dry air test it is known that at dead end the air pump will produce a 0.29-in. vacuum and that if 26 cu. ft. of dry air be admitted per min., the vacuum will fall 0.71 in. to an absolute pressure of one in. Saturated water vapor at 90 deg. F. has an absolute pressure of 1.41 in., so the pressure in the condenser with an inleakage of 26 cu. ft. of dry air per min. will be 1.41 in. + 0.71 in., or 2.12 in. of mercury. Examining Fig. 1, it will be noted that the vacuum actually produced under these conditions is 2.16 in. of mercury. Expressed algebraically, P = Pw + (Pa—Po), where P is equal to the absolute pressure produced in the condenser, Pw the pressure of saturated water vapor at the temperature of the air pump suction, Pa the absolute pressure produced by the steam jet when handling the same weight of dry air on orifice test, and Po the pressure which the air pump will hold on dead end. Referring again to Fig. 1, it can be seen that this straight line relation holds up to a capacity much in excess of that usually given for this air pump.

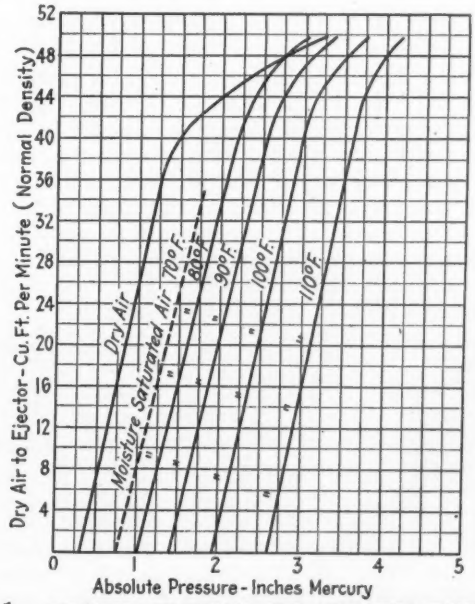


FIG. 1. CAPACITY OF STEAM JET AIR PUMP HANDLING WATER SATURATED AIR AT VARIOUS TEMPERATURES

*Engineer, Wheeler Condenser & Eng. Co.

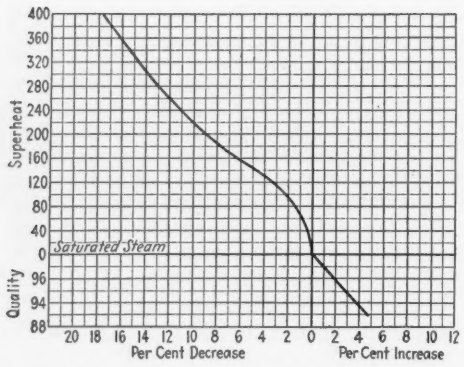


FIG. 2. VARIATION IN STEAM CONSUMPTION OF STEAM JET AIR PUMP WITH WET OR SUPERHEATED STEAM

Steam-jet air pumps are not usually designed to operate against more than 1 lb. back pressure, however, a specially designed pump may be made to exhaust against a higher back pressure.

Steam Jet Pumps Operated on Reduced Pressure

Air pumps of the steam jet type are usually designed to be operated with steam at less than boiler pressure. It is customary to use a reducing valve between the boiler and the steam jet air pump, but in stations where the steam pressure is appreciably constant, a reducing orifice may be substituted for the reducing valve. If the steam is wet or superheated, the steam consumption will vary, as shown in Fig. 2, being decreased with superheated steam and increased with wet steam.

Method of determining the size air pump suitable for a given condenser is largely empirical, as the air inleakage

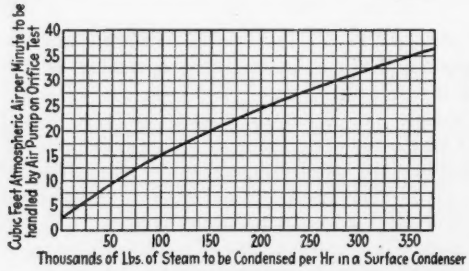

Cubic Feet Atmospheric Air per Minute to be handled by Air Pump on Orifice Test
Thousands of Lbs. of Steam to be Condensed per Hr in a Surface Condenser

FIG. 3. SIZE OF AIR PUMP REQUIRED FOR DIFFERENT SIZE CONDENSERS

is variable, depending upon the care taken to keep the turbine and condenser joints in good condition. The number of pounds of steam condensed per hour at full load is generally used as a basis for calculation (in spite of the fact that little air enters directly with the steam), on the assumption that the size of the condenser, and therefore the chance for air inleakage, is proportional to the amount of steam to be condensed. The curve in Fig. 3 gives a safe value of the air handling capacity to be installed with condensers of various sizes. The capacity in cubic feet of atmospheric air per min., of the steam jet air pump as shown by a dry air test is plotted against the pounds of steam to be condensed per hour in the surface condenser. That air pump should be chosen which will have the desired free air capacity at the vacuum which it is expected to obtain. In other words, if the temperature of the cooling water is such that the highest vacuum possible is 28 in., the air pump need only have the required free air capacity at 28 in., whereas if 29 in. vacuum were obtainable, a larger air pump with the required capacity at 29 in. should be chosen. For jet condensers an air pump twice as large as usually installed.

Diesel Cylinders Cooled With Rain Water

Oklahoma Plant Cools Jacket Water by Means of a Pipe Coil Placed in the Base of a Cooling Tower

FIVE OKLAHOMA towns are to get electric power from the new Diesel engine plant of the Inland Utilities Co., at Hobart, Oklahoma. Current is generated at 2300-v. and stepped up to 13,200-v. in three, single-phase Moloney transformers, each being rated at 350 kv.a. The old plant at Hobart, which is being superseded by the new Diesel plant, consisted of two horizontal return tubular boilers, which were fired with oil, two steam engines and a semi-Diesel engine. The machinery in the old plant will soon be dismantled and the building will probably be used for storage purposes.

The new plant is constructed of brick and steel, the floor being of concrete, and the roof, which is of the pitched type, is laid with corrugated asbestos sheet roofing. Engine and generator equipment now consists of Fairbanks-Morse & Co. units. Two units are of the style VA type and are six-cylinder Diesel engines, rated at 300 hp. and 257 r.p.m. Each is connected to an alternator, rated at 200 kw., 80 per cent power factor, 2300 v., 60 cycles, and 3 phase. The third unit is also of the style VA Diesel but it is a three-cylinder engine and is rated at 150 hp. at 257 r. p.m. Direct connected to it is a 100-kw. alternator, which is otherwise rated the same as those on the larger units. It is of interest to note here that it is not planned to extend the building when increased generator capacity is installed, instead the size of the engines and generators will be increased, the older and smaller units, which will then be taken out, will be made use of by other plants owned and operated by the company.

Direct Connected Exciters to Be Added

Excitation for these units is now furnished by a Fairbanks-Morse motor-generator set, the induction motor of which is rated at 20 hp., 220 v. and 880 r.p.m., and the shunt wound generator is rated at 15 kw. and 125 v. Belt connected to the shaft of the 150-hp. engine is a 10-kw. exciter. This is to be removed, however, and each engine shaft is to be equipped with a direct connected exciter. The motor-generator set will then be used only as a spare.

Air for starting is stored at 230 lb. pressure in six air receivers. Compressed air is obtained by means of a single stage compressor, direct connected to a Fairbanks-Morse, type Z engine. In order readily to check the temperature of the exhaust gas from each cylinder, a Brown indicating pyrometer is mounted on the wall at a convenient point. It is connected through multipoint switches, so that it is but a second's work to know the temperature in the exhaust pipe near each cylinder.

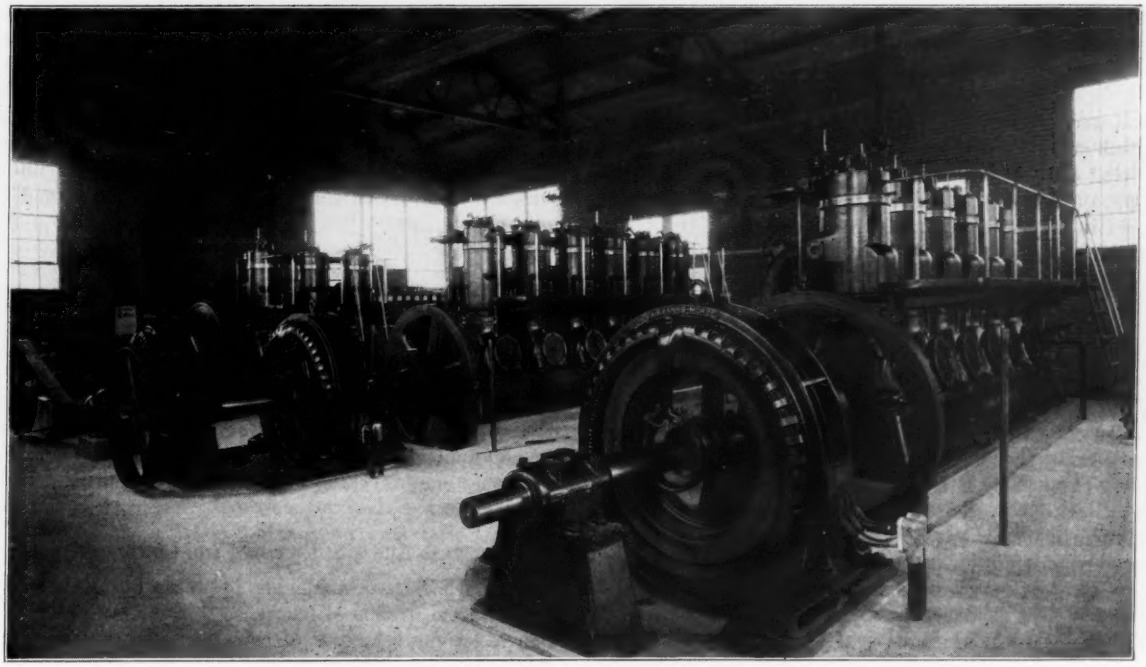


FIG. 1. TWO SIX-CYLINDER AND ONE THREE-CYLINDER UNITS ARE IN OPERATION

Cooling water for the cylinders is obtained by catching rain water and storing it in a 16,000-gal. concrete cistern. This water is drawn from the cistern by means of three pumps, two of which are double-suction, single-stage, 3600 r.p.m., and rated at 100 gal. per min. each. Each is direct connected to a 5-hp., 220-v. induction motor. The third unit is single stage, single suction and is rated at 60 gal. per. min. It is driven by a 3-hp. induction motor. These pumps all discharge into a common header, which is connected to a cooling coil located in the tank at the base of the cooling tower. This cooling coil is made of 2½-in. pipe and there is 2 ft. of pipe for each rated horsepower of the engines.

From the cooling coil the water goes to an open tank on the cooling tower. This tank is provided with an overflow to the rain water cistern and is located at such a height that there is a 7-lb. head on the engine cylinder water jackets. The water leaving the cylinder jackets flows back by gravity to the rain-water cistern. Any one of the circulating pumps may be used to supply water to any one of the engines.

Water for the cooling tower is purchased from the city of Hobart. It is elevated to the top of the tower by means of a single stage, 200 gal. per min., centrifugal pump, which is direct connected to a 5-hp., 1800 r.p.m., 220-v. induction motor. The base of the cooling tower is 12 ft. by 44 ft. During periods of light loads or when the weather is cold, it is not necessary to use the cooling tower; further, the temperature rise of the jacket water is normally so small that the cooling tower water pump can be out of service for several hours at a time, therefore it was decided that it was not necessary to install a duplicate pump for that service.

Thirty-four thousand gallons of fuel oil is stored in three steel tanks, supported on concrete pedestals. The oil flows by gravity to three steel tanks, of 300-gal. capacity each, one of each being located underground near an exhaust conduit from an engine. These small tanks are so located because the oil used is of low gravity and the heat from the exhausts makes it easier to handle. The fuel pump on each engine draws its supply of fuel oil from its respective 300 gal. capacity tank.

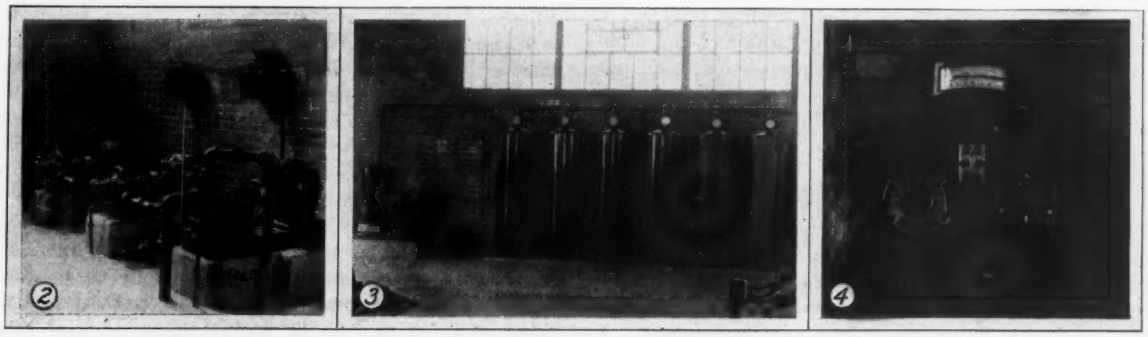


FIG. 2. MOTOR-DRIVEN PUMPS HANDLE RAIN WATER FOR JACKET COOLING FIG. 3. STARTING AIR IS OBTAINED FROM SIX TANKS FIG. 4. INDICATING PYROMETER SHOWS TEMPERATURE OF EXHAUST GAS

The exhaust pipe from each engine discharges into a 36-in. square concrete pit, which is vented by means of a corrugated galvanized iron pipe 20 in. in diameter.

Lubrication for the engine is automatic and is an integral part of each engine. All of the cylinder oil passes continuously through a filter. The crank shaft bearings are ring oiled and the oil reservoirs of these bearings are interconnected so that the oil always stands at the same height in all the reservoirs.

The station switchboard was furnished by Westinghouse Electric & Mfg. Co. and consists of seven panels; one for the exciters, one for street lights, three for the main units; one for the high line circuit and one for the business and residence circuits in Hobart. Spare engine parts, which will be kept on hand, will be as follows: two crank bearings, 18 piston rings, one extra cylinder head, two combustion chambers, six spray nozzles, and 12 spray nozzle tips.

Engineering Opportunities and Viewpoints

To Be Successful an Engineer Must Think and Accept Responsibility. By Louis R. Lee

EACH YEAR OUR universities and colleges graduate larger classes in engineering and the query often arises as to the opportunity these young engineers may have. It probably is a fact that today a greater percentage of university graduates hold some degree in engineering than in former years. It is also a fact, however, that there are now more things in our everyday life which require technical knowledge to understand and appreciate than ever before. Much has been said about what constitutes the engineering courses. I believe that the existing courses are in general satisfactory and that it does not require further argument on that point. I believe, however, there are many different viewpoints that the young engineer can take, some of which are much better than others.

Probably the first idea he should get is that in the majority of cases opportunities for advancement are equal. That is, some graduates may go out and through acquaintanceship get started quickly in a good position. It will, however, be strictly up to this man to secure advancement or to hold the opportunity which he has been given. Therefore, the less fortunate engineer who comes along and secures his own opportunity, if he has the ability, personality and various other qualities, which he will need, will get along and in the course of a few years will have advanced as far as the more fortunate one.

There is also an idea which is quite generally accepted that I believe is wrong, and that is, that the engineers who fail, do so because they are incompetent. I do not believe that is so; that is, they do not fail through incompetency as the term "incompetency" should be defined. I have known of only one or two cases among all of the engineers with whom I have been associated that failed because they were really incompetent and unable to understand or carry out engineering ideas. I have known, however, a good many who have failed for other reasons. It frequently happens that the engineer lacks tact and diplomacy; he is unable to investigate a proposition, meet people and get their viewpoint, make a strict and accurate report of the situation without ruffling the good nature of many of those that he meets. In other words, as he goes along he makes a poor impression.

Many times this impression is in error; the intentions of the man are good and he deserves a much better deal than he gets but the fault is his own, as he apparently is unable to give consideration to this phase of the matter. If such a condition is incompetence, then I would say that many engineers fail because they are incompetent. In still other cases failures have been caused through lack of attention to the details or inaccuracy of statements and in these cases the persons do not intend to be inaccurate or negligent in their working out of details. They just do not appreciate the value of such things. There are still other engineers who fail because they can not write a good letter.

Letters Are a Substitute for Conversation

There have been altogether too many instructions put out as to the writing of letters, so that it is not my intention to lay down any set of rules for letter writing but I think that if we would all appreciate that a letter is only a substitute for a personal call and that nothing should be put into a letter that we would not think of saying to a person when we would meet him in his office, then our letters would be much more satisfactory. The engineer is supposed to be a person of accurate language who thinks logically, therefore if he writes a letter he should use accurate language logically arranged and he should give all the information that is necessary for the receiver of the letter to consider the proposition and answer it if it requires an answer. I have little sympathy for the idea that a letter should be of a certain length; a letter should be as long as necessary to describe thoroughly the subject under consideration. If it takes five pages to state the matter clearly and accurately, then five pages should be used. If it can be done in less space it is better to do so but to shorten a letter to put it all on one page as an arbitrary rule I think is extremely short sighted.

There is also the question of credit. The engineering graduate has just finished receiving credit for work done. It may have been necessary while in school to see that when a course was finished due credit was recorded. I have known of cases where the personal investigation of a student prevented errors which would have caused embarrassment later on. Now, in actual work the condition is different. It is not necessary for the engineer in business to spend much time, if any, looking up or ascertaining whether he is getting due credit for the work he is doing. I can recall an example along this line. An engineer had been recommended to a position and he was doing a little investigating as to the character of the company he was going with and the personality of the men in charge of this business. Upon interviewing a former employe of this company he was told that it probably was a good opportunity but that the particular individual in charge of the work would claim all the credit and that he might work there for many years and never get credit for anything. This seemed to the engineer a rather hard situation and worried him somewhat but as the other phases of the situation seemed to be favorable, he decided that he

would waive this question of credit and let the head of that company claim all the credit that he wished. The result was that this engineer found the situation not as bad as the former employe had stated and he found that it made little difference who got the credit. He got just as much satisfaction out of getting things done right and he learned much by his experience and gained promotion from time to time, apparently just as much as if someone came around at regular intervals and recited to him the appreciation of the company, giving him formal credit for work done.

This may be an exceptional example but I have known a great many engineers and there are probably others who are not engineers who have had the same idea, worrying over the fact that they had done a great deal of good work for which they had received no credit. That is, I gather from their statements that nobody either came around and formally congratulated them on what they had done or marked up in some imaginary book of records their names as being responsible for such and such work. I think that the quicker the engineer gets right on this phase of the matter the better for himself and for those with whom he is working.

Engineers Must Learn to Think

One far more important phase of engineering is independent thinking. Every engineer should try to form his own ideas. Concerning a great many propositions with which he will have to do, he will not be asked for his ideas; that is, he will not be asked directly; notwithstanding, he can imagine he has been asked and form a mental report as if he were going to be entirely responsible for it and watch the ultimate outcome. The engineer should not jump at conclusions and form his idea of things without thorough investigation and without due consideration of the opinions of others who may be in a better position to know about the matter than he is. Still he must appreciate that it is possible for a group of men who are seemingly thoroughly familiar with the situation to arrive at a wrong conclusion, therefore it is up to him to seek his own data and draw his own conclusions. It will not help him to let someone else arrive at conclusions which he accepts without due consideration.

Since engineers deal largely with things mechanical he should have a special liking for this sort of thing and as he goes around from place to place he should gather ideas which have to do with mechanics. If he runs into a proposition which he has nothing to do with and has a little time to look it over, he should investigate to find the element in it that pertains to engineering and see what others may be doing and why they are doing it. It, of course, is unreasonable to expect that the engineer should eternally, in business hours and out, think and work upon engineering matters. That is not necessary but it is equally unreasonable for the engineer never to consider mechanics and things of a like nature in his off hours. If, in going around, he sees none of the progress in things of this kind he must not have the natural liking for engineering which is necessary if he is to enjoy that kind of work and make a success of it.

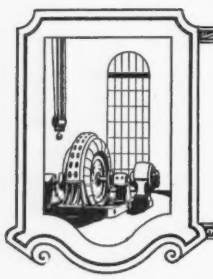
The engineer must also recognize responsibility. It is particularly important that someone in every project accept full responsibility and having accepted it that he take the necessary steps to be sure that all of the necessary things are being done to bring this project to a successful conclusion. If by chance the conclusion is not successful, it is just as important that this engineer accept the responsibility and acknowledge the blame or his share of it. If he is unwilling to do this, then he does not deserve the credit for the successful conclusion of other propositions. If the engineer feels that he is not qualified to assume full responsibility in any given case, it is no disgrace to acknowledge this and in acknowledging it to do so before it is too late.

The element of time has much to do in engineering and recognition of the time when certain parts of a project should be finished is just as important as understanding what these parts consist of. If often happens that the most successful man in charge of work is the one who recognizes what the work consists of and secures the co-operation of others to get it done, rather than to try to work it all out himself, delaying progress and running the chance of making mistakes. Securing the co-operation of interested parties in a project and checking up of the progress of a project are probably the most important phases of getting large operations done in record time. In most cases it is worth considerable to get a job done on time or ahead of schedule rather than a little or a great deal late. Most projects are contemplated and considered longer than they should be and approval is usually secured at a late date. This is necessarily so because the larger the project the more people are interested in it and the greater the length of time required to get it finally agreed upon and approved. Therefore, there is usually proportionately less time to work out the larger project than the small ones and there is much greater need of their being completed on a given date than the smaller ones.

In conclusion, the successful engineer should have an interest in engineering work. He must not be afraid of taking responsibility for anything that he has to do with whether it succeeds or whether it fails. He should give little or no consideration to the question of credit. If someone comes along and claims credit for it, let them do so. Sooner or later the truth will come out. In every proposition the engineer ought to form his own ideas after giving thorough consideration to all people interested in it and all the facts that can be found, but the conclusion he comes to should be his own conclusion not influenced by someone else except as the facts which someone else may give may influence his conclusion. In other words, he should be influenced only by facts or conditions as he actually finds them by careful and thorough investigation.

Under the direction of the Board of Municipal Water Works, five artesian wells have been drilled at Winona, Minn., with a depth of 500 ft. Four of these are 10 in. wells and the other is 14½ in. Indiana air lifters will be installed in these wells to raise the water to a 2,000,000 gal. reservoir now being constructed. Two Chicago pneumatic air compressors will be installed, together with a 6,000,000 gal., pumping unit and a 350 hp. boiler. It is expected that coal handling equipment will be installed with the new boiler. F. C. Donath is chief engineer of the Board of Municipal Water Works.

Some men can't grasp opportunities without choking them to death.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Modern Switchboards Demand Care in Wiring

ACCESSIBILITY AND NEATNESS GOVERN LAYOUT OF CONDUCTORS, BRACKETS, CLEATS, TERMINAL STUDS AND OTHER DEVICES DESCRIBED. BY C. S. BOUSUM*

ON ACCOUNT of the growing tendency toward narrow and more compact switchboard panels, the problem of placing wire on the rear of the board so that it is neat, accessible and easily traced, is constantly becoming a more difficult one. In the olden days, space requirements were not given much consideration. Panels were wide and the asbestos insulated wires were spaced ½ in. apart and held to the panel by porcelain or wooden cleats. A change in the insulation of the wire now permits the bunching of wires under micarta or steel cleats without danger of short circuits between wires of opposite polarity.

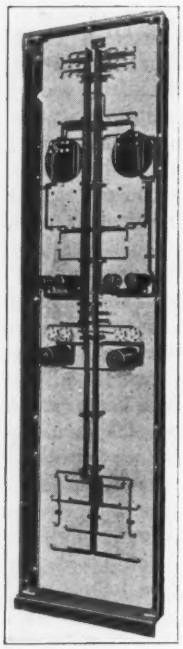


FIG. 1. "L" BRACKET TYPE WIRING, SHOWING WIRES CLEATED ON THE BACK SIDE OF SWITCHBOARD

FIG. 2. METHOD OF SHARPENING DRILL FOR DRILLING HOLES IN SLAB MATERIALS

The original method of wiring switchboard panels was to cleat the wires flat against the panel. This method is quite generally used at the present time where sufficient space is available. Other schemes have been tried from time to time, such as bunching of wires in conduits which in turn were fastened to the rear of panels, the conduits being cut out at points to permit connecting to the different pieces of apparatus. Cabling the wires along the angle or channel iron frame was another practice. All these schemes, although often making a neat and workmanlike job, usually made the conductors inaccessible and made changes and repairs difficult.

At the present time the two most generally used methods of placing and supporting wires on the rear of panels, are the flat panel method and the "L" bracket type of wiring. Space permitting, the flat panel type is the neatest and most accessible method of wiring a switchboard. This method of wiring should be used as far as possible on all panels, but should not be double decked; that is, one layer of wire should not be placed on another. Usually, this fact may be determined during the layout period. In order to make the wiring accessible, it may be necessary to use the "L" wiring bracket type. This method provides for carrying a large number of wires on a panel, when space is quite generally taken up with switches, studs and other apparatus, usually mounted on or extending through the rear.

In this scheme, which is shown in Fig. 1, the wires are cleated on the long side of the "L," the short side being fastened directly against the switchboard panel by means of expansion sleeves or other approved holders. Here, however, care should be exercised to see that the "L" bracket wiring is not triple decked, as obviously there would be an inner row of wires which would be difficult to trace and also inaccessible. If, in the "L" wiring bracket scheme, it is desired to support more wires than would be possible with a single row of "L" brackets, a double row is desirable. The rows, however, should be located not less than 3 in. apart, so as to permit access to the inner row of each line of wires. In order to hold the wire rigidly in line, it is desirable to wrap wax ends around the main batch of wiring at the different points where the individual wire leaves the main spine. It is also a good plan to run the longest wires at the end of the "L" brackets, thus adding considerably to the appearance of the job when completed. Make as few bends as possible and run the wires in a neat and orderly manner, binding them together with cleats or wax ends wherever necessary to hold them firmly in position.

When removing the insulation from the ends of wire or cable, extreme care should be used to insure that the wire is not nicked. Perhaps the best results will be obtained by removing the insulation as one would sharpen

* Switchboard Engineering Dept., Westinghouse Electric & Mfg. Co.

a lead pencil. This point should be carefully checked during the course of wiring unless an approved wire insulation stripper is available. If it is necessary to work with insulated wire which frays badly, care must be used in order that the ends of the wire do not become frayed, resulting in a poor looking job. Clips are often provided which cover the ends of insulation and also permit fastening the wire to terminal studs; in using such clip terminals, however, it is necessary to space terminal studs far enough apart so that there will be no danger of accidental contact between terminals of opposite polarity. Crimp washers are often used for holding wires on studs. These washers, however, do not cover the ends of the insulation, but do permit the extremely close formation of terminal studs and, if non-fraying insulated wire is used, make an exceedingly finished job when installed.

The type of terminal stud used is a matter of choice. The studs may be sunk directly into the slab material as indicated in Fig. 3, or numerous studs may be mounted on an insulating base, the base in turn being mounted on the rear of the panel. Both of these schemes are good but, obviously, the sunken studs are simpler and make a neater job.

As each terminal stud should be marked indicating the point which it represents on the switchboard diagram, marking by painting will no doubt be found desirable. Tags of a metal or fiber material are often used on the stud to identify them but these are frequently lost in the process of wiring or checking, and long experience indicates that painting on the panel near the stud insures the identification being there when it is needed.

Where there is any possibility of vibration after panels are placed in operation, it is necessary to provide a form of lock washer or lock nut for all connections. The lock washer is probably one of the best methods of holding a nut firmly on the small studs and should generally be used.

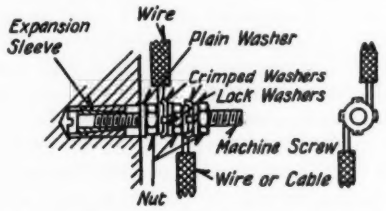


FIG. 3. TERMINAL STUD IS SUNK INTO SLAB

In order that neat wiring may be obtained, it is necessary to have a good workable layout of cleats and studs on the rear of panels. By a workable layout is meant one which will permit the neatest possible job with the smallest number of bends. The cleats should be so arranged that the wiring will not cover small fuses, resistors, etc., as it may be necessary to remove or replace them from time to time when the panel is in operation. As better diagrams made for panel wiring show the wires in approximately the same physical location as that in which they should be placed on the rear of panels, there is ordinarily no excuse for a poor layout. In the layout period, care should be taken to see that the proper spacing between cleats is arranged for; ordinarily the best results will be obtained by leaving perhaps 10 to 12 in. between the cleats. A further improvement on the rear will be obtained by arranging the cleats on the same horizontal center line across the rear of all panels of a multi-panel switchboard.

The type of cleats used in wiring has much to do with the general appearance of the rear of panels. What is probably the latest development in wiring cleats is shown in Fig. 4. These cleats are designed to hold any number of wires from one to eight, by means of a single screw which is placed in the center. The cleat is made from a high grade of spring steel with a baked enamel finish. They hold well and are considered a great improvement over the old forms.

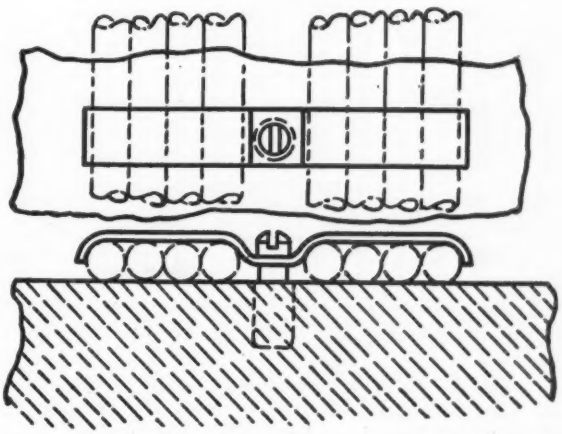


FIG. 4. LATEST TYPE WIRING CLEATS ARE MADE OF SPRING STEEL

The method of holding cleats to slate and marble panels offers a wide field of choice, such as the steel expansion sleeve, lead expansion sleeve, lead plug sleeve, brush-nail holding device, and the self tapping screw. All these methods are good, and the selection usually depends on one's preference.

It may be of interest to know how to sharpen twist drills for drilling holes in the slab material. Figure 2 illustrates this clearly.

Selection of wires should then be considered and here there is the choice of either cambric or rubber insulation with a flame-proof outer braid. Both of these insulations are widely used for switchboard work. They may be obtained in either gray or sleek black, the latter finding most favor, on account of its uniform color and appearance.

When running small wiring to the different points of connections on the rear of panels, such as terminal studs and meter studs, the ends of the wire are usually formed in a loop which is bent to the right. This prevents the uncoiling of the loop when the nut is tightened on the stud. Ordinarily this wire is looped around studs up to and including ¾ in. in diameter. Above this size it is rather difficult to get a neat appearing job. Consequently, the wires are usually connected to small screws which have been placed in the stud nuts.

It is not desirable to have more than one wire looped around a stud, large or small, and in order to carry this out it is often possible to run a continuous wire from one stud to another instead of individual short wires.

Instrument and control bus wiring which runs across the rear of all panels should be installed in such a manner that it will not sag after being placed in position.

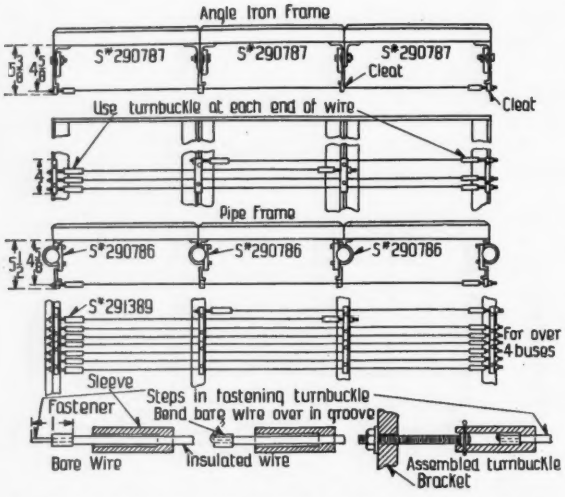


FIG. 5. INSTRUMENT AND CONTROL BUS WIRING ARRANGED ON INSULATED TURN BUCKLE TO PREVENT SAGGING

An excellent way to prevent sagging is to arrange an insulated turnbuckle at one, or preferably at both ends of the wire. Experience has proven that excellent results are obtained in this way. Although there are other methods of obtaining similar results, this arrangement works out well. As will be noted in Fig. 5, each wire is held individually from either end, and fastened to brackets which are especially designed for this purpose. After the wires are stretched in position, which may be either in a plane parallel or perpendicular to the rear of panel, each turn buckle is lettered or marked with the same designation that is indicated on the switchboard diagram. Such an identification makes it possible to check readily the wiring during the course of erection in the field, and later by the operator or maintenance division.

The method of terminating conduits, instruments and control cable at the rear of the switchboard panels has to be considered, and also the method of terminating the wires on the switchboard at the terminal board or posts near the bottom of panels. It is necessary to have either studs sunken in the rear of the panel or a terminal board mounted on brackets so that the studs are accessible for making connections from the instrument control cable which come in at the bottom. If there is sufficient space directly on the rear, the sunken studs are desirable. If not, it is necessary to use terminal boards which extend out from the board a sufficient distance from the panel so that there is sufficient room for the workmen to connect the wires from the panel to the board, and also for connecting the cable which usually comes up from below. The terminal board may also be fastened on a sheet iron panel at right angles to the rear of panel. Such an arrangement is quite generally used on control desks, and certainly permits accessibility on the rear, making it possible for the wireman to perform a neat job of wiring both from the panel to the terminal board and from the terminal board to the cable connections. The terminal board may also be fastened on brackets which run directly across and parallel with the rear of each individual panel.

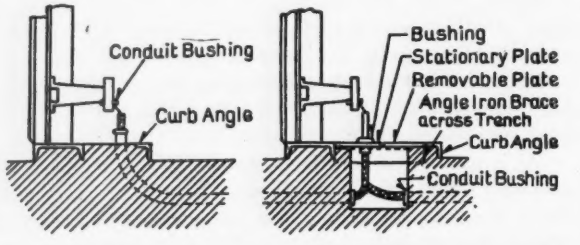


FIG. 6. METHOD OF TERMINATING CONDUIT IN TRENCH WHICH EXTENDS ENTIRE LENGTH OF SWITCHBOARD. CABLES MAY BE CROSSED IN TRENCH OR IN REAR OF PANEL

After the position and location of the terminal board have been determined, it is then necessary to select the best method of terminating conduit and control wiring in the rear of panel. In order to obtain the neatest job, it is necessary that all conduits should terminate at a uniform height and in a straight line down the rear of the switchboard. Obviously, this scheme does not permit the crossing of cables above the floor without spoiling the appearance of the rear.

Figure 6 shows a desirable scheme; as will be noted, the conduits terminate in a trench which extends the entire length in the rear of the switchboard. The trench may be covered with sheet iron slabs having holes drilled in them to set bushings through which the instrument cable is run. With such an arrangement the cables may be crossed in the trench instead of on the rear of panels. As will be noted, the removable plate makes it possible to get in the trench without disturbing the cable arrangement. Another scheme is shown in Fig. 7 where the conduits are run underneath the floor and terminated at a steel plate directly in the rear of the panel. With such an arrangement condulets should be used, which provide an excellent outlet for the small wires. It is also necessary in this arrangement to have the conduit terminate uniform in height and in a straight line back of the switchboard panel. A curbing arrangement may be placed parallel with this trench the same as shown in Fig. 6.

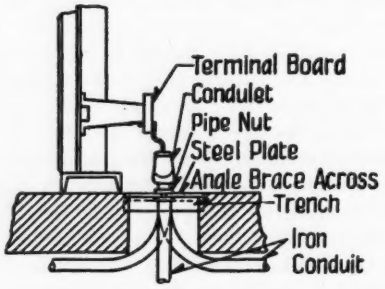


FIG. 7. ANOTHER METHOD, IN WHICH CONDUITS RUN UNDERNEATH FLOOR AND TERMINATE AT STEEL PLATE DIRECTLY IN REAR OF PANEL

TOO MANY AMERICAN homes are poorly lighted, says the Eyesight Conservation council in a recent report made on a national survey of lighting conditions in the United States. Industrial lighting is still far below modern standards, but it is in homes and schoolrooms that illumination has been most seriously neglected, particularly in view of the importance of good light in the healthy development of growing children.

THE EMPLOYE who fails to study and learn, is like the autoist who stops buying gasolene for his car.

Experiences with Protective Reactors

ACCOUNTS OF ACCIDENTS SHOWING EFFECT OF REACTORS IN KEEPING POWER CONCENTRATION SO THAT THE DAMAGE WAS LOCALIZED

ONE OF THE MOST interesting papers to the operating electrical engineer presented at the recent Spring Convention of the American Institute of Electrical Engineers at St. Louis was the one by James Lyman, Leslie I. Perry and A. M. Rossman, outlining their experiences with protective reactors on a large power system.

In February, 1914, the authors presented before the American Institute of Electrical Engineers, a paper entitled "Protective Reactances in Large Power Stations." In October of the same year they presented a second paper entitled "Protective Reactances for Feeder Circuits of Large City Power Systems." These studies were made for the purpose of determining the best reactor system for two large steam power stations on which preliminary design studies were then being made. In these studies it was shown that after a certain number of generators are connected to a ring bus, with reactors connected between adjacent generators, the number may be increased to infinity without appreciably increasing the amount of current flowing into a short circuit on the bus. Based on the reactance values of the generators and bus bar reactors which at that time seemed most desirable and which experienced has changed but little since then, the following figures were derived.

1. After three generators are installed, the number of generators can be increased to infinity without increasing by more than 50 per cent the amount of current that can flow into a short circuit on the bus.

2. With an infinite number of generators, the maximum amount of current that can flow into a short circuit on the bus is about 3½ times the short circuit current that can be obtained from a single generator.

RING BUS SYSTEM ADOPTED

The system of connections finally adopted was a ring bus with five per cent bus reactors between adjacent units, based on turbo-generator units of the order of 25,000 kw. to 30,000 kw. at 0.8 power factor, and a radial system of feeders with three per cent feeder reactors, based on feeders of 6000 kv.a. to 7500 kv.a. at 11 kv. to 13.2 kv. The bus reactors are shunted by oil circuit breakers which are so controlled that when one or more generators are disconnected from the bus, the corresponding set of adjacent bus reactors is automatically shunted, thereby preventing more than one set of bus reactors from being in circuit between any two adjacent running generators. This scheme of connections with eight generators in service is shown diagrammatically in Fig. 1. In Figs. 2 and 3 are shown the connections when but one-half of the generators are in service. This system of connections limits the flow of current into a short circuit on a generator or on any section of the bus after a lapse of 0.1 sec. to a value of approximately 750,000 kv.a. The flow of current into a feeder short circuit is limited to a value of approximately 250,000 kv.a.

In the paper that was presented at the recent meeting at St. Louis, the authors recounted some of the actual operation experiences in power stations where this reactor system has been in service for several years.

In 1916 construction work was started on the Windsor Power Station of the American Gas and Electric Co., and the West Penn Power Co. This station was placed in operation during 1917 with one 30,000-kv.a. turbo-generator. The following table shows its growth:

YEAR	UNITS STARTED OPERATION	TOTAL KV.A. CAPACITY
1917	One—30,000 kv.a.	30,000 kv.a.
1918	One—30,000 kv.a.	60,000 kv.a.
1919	Two—33,333 kv.a.	126,666 kv.a.
1923	Two—33,333 kv.a.	193,333 kv.a.

During the years that this station has been in operation, there have been several short circuits of sufficient

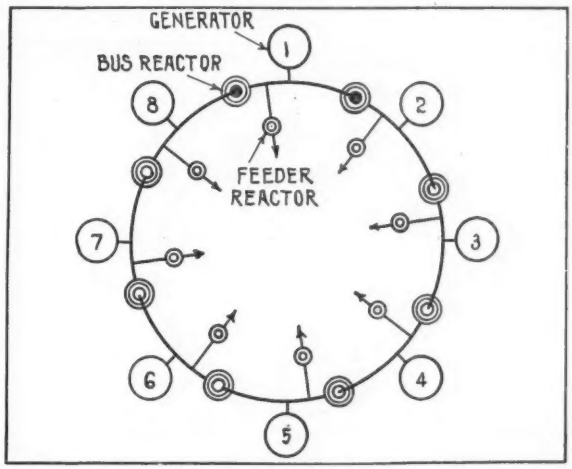


FIG. 1. SCHEME OF CONNECTIONS—ALL GENERATORS IN SERVICE

severity to test the effectiveness of this scheme of reactors, and to demonstrate its ability to keep down the flow of short circuit current to a value well within the interrupting capacity of moderately heavy duty oil circuit breakers and to localize the damage to the immediate vicinity of the arc. Below are given brief narratives of several of these short circuits.

ACCIDENTS AT WINDSOR

1. On August 15, 1919, with three generators running, an employe accidentally placed a ladder against a high-tension lead in the 66-kv. switchyard. The circuit breaker on the low-tension side of the transformer bank, feeding these bus bars, tripped and cleared the trouble. A few minutes later the low-tension breaker was again closed. Immediately a quantity of oil squirted out of one of the transformers between the tank and cover. The 11-kv. circuit breaker again tripped out and cleared the circuit. An examination of the damaged transformer, which was one unit of a 20,000-kv.a. bank, showed that the lower turns of the 11-kv. coils were badly damaged both by burning and by the destructive forces of heavy currents. The high-tension coils, although undamaged, were somewhat displaced. The total damage was confined to the one transformer.

2. On May 17, 1922, with four generators running, one of five 3-conductor 500,000-cir. mils 11-kv. cables,

feeding a 30,000-kv.a., 132-kv. transformer bank, failed under emergency overload, taking with it several of the adjacent cables. The 11-kv. circuit breaker cleared the trouble from the bus. The following morning a cable on a duplicate transformer bank of the same capacity and voltage failed in a similar manner. In this case also the 11-kv. oil circuit breaker cleared the trouble from the bus bars. These cables were connected directly to the 11-kv. bus bars without series reactors. In neither case did the damage extend beyond the cables and their enclosing conduits.

3. On September 1, 1922, lightning broke down a bushing on one of the 66-kv. oil circuit breakers, causing failure to ground. The overload relay on the 11-kv. side operated properly, but the tripping relay on the 11-kv. oil circuit breaker was out of adjustment and failed to operate. Four generators were connected to the bus at the time, and the flow of current was sufficient to burn out the

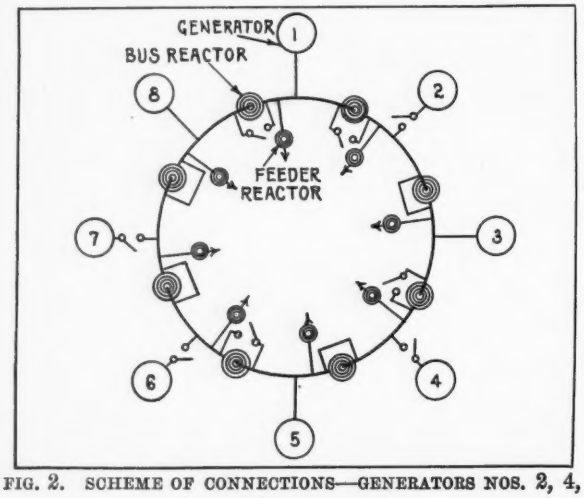


FIG. 2. SCHEME OF CONNECTIONS—GENERATORS NOS. 2, 4, 6, AND 7, SHUT DOWN

windings of two transformers of a 20,000-kv. bank feeding the 66-kv. bus. The pressure inside of the tanks was so great that the manhole covers were blown off in quick succession, and each transformer sent up a column of flaming oil higher than the stacks of the power-station building. It was several minutes before the switchboard operators discovered the location of the trouble and cleared the transformer bank from the bus, and some time before the oil fire in and around the transformers could be extinguished. Here again, the damage was limited to the two transformers and the area over which the flaming oil had spread.

4. On November 13, 1923, there occurred the most serious electrical trouble which had developed since the station was placed in operation. With all six generaors and a seventh duplicate machine operating as a synchronous condenser—a total of 223,333-kv.a., connected to the bus—an arc was started by the breakdown of an insulator. The subsequent arcs and flames established a short circuit between the three phases of the main 11-kv. bus. More than a minute elapsed before the switchboard operators located the trouble and killed the power-station bus. A subsequent examination showed that the damage was confined entirely to the short section of bus across which the arc had played. A lighting fixture on the ceiling of the room directly above the arcing bus was not damaged; neither was the reserve bus structure which was separated from the main structure by an aisle space of eight feet. The circuits were, accordingly transferred to the reserve bus and service was resumed within 48 min.

Faults at West End Power Station

The West End Power Station of the Union Gas & Electric Company of Cincinnati was placed in operation in 1918, with two 30,000-kw. (31,250-kv.a.) turbo-generaor units. In 1920, a third unit, and in 1921, a fourth unit of the same capacity were placed in service, making a toal present capacity of 120,000 kw. (125,000 kv.a.).

All faults on West End Power Station have occurred on the feeders beyond the feeder reactors. Thus, the maximum fault kv.a. has been limited, in all cases, by the feeder reactors which are rated at 0.76 ohm on a basis of 13.2 kv. (three per cent on 300-amp.). Three of the most severe faults are listed below.

1. On July 18, 1921, at 11:42 a. m., a three-phase short circuit developed in a 400,000-cir. mil cable approximately 1½ mi. from West End Power Station. At the time, there were two generators running with a total load of 45,000 kw., and two bus reactors in service. The feeder-oil circuit breaker opened to clear the fault without signs of any great disturbance on the rest of the system.

2. On December 15, 1923, a short circuit developed in a 400,000-cir. mil cable approximately ½ mi. from West End Power Station. There were three generators running at the time and three bus reactors were in service. The fault current was 6000 amp. in each phase, and was broken by the opening of the feeder-oil circuit breaker; however, there was a sufficient force developed between two of one set of feeder reactors to pull them together with a resultant breaking of the concrete side slabs. These reactors were spaced horizontally one foot apart and were not fastened to the floor. The voltage on the directly affected section of bus was maintained at 70 per cent of normal, and the rest of the system did not suffer any serious disturbance.

3. The most severe fault that the system has suffered occurred on October 31, 1924, at 9:57 a. m. This was a three-phase short circuit on two adjacent 400,000-cir. mil cables at a point where they changed from underground cables to overhead open lines. At the time there were four generators running and four bus reactors were in service. The two cables were connected to different sections of the bus, so that two of the generators were connected directly to the faulty cables without interposing bus reactors. The fault current was 4300 amp. per phase in each cable (8600 amp. from the system). The bus voltage dropped to 77.5 per cent of normal. One hurling pump motor which was connected to the same section of bus as one of the faulty cables, was tripped out by an undervoltage relay. No other auxiliary motors were affected. The relays operated correctly to open the oil circuit breakers on the two faulty cables.

This year, Miami Fort Power Station, with an initial installation of two 38,000-kw. (44,705-kv.a.) turbo-generators will go into service about 20 mi. west of West End Power Station. This station will have the same system of bus and feeder reactors that has worked out so successfully at West End Power Station.

In the winter of 1919-1920 the Northeast Power Station of the Kansas City (Missouri) Power & Light Company was placed in operation with two 20,000-kw. (25,-

000-kv.a.) turbo-generator units. The following table shows the growth by years of this station:

1919—One 20,000-kw. 25,000-kv.a.
1920—Two 20,000-kw. 25,000-kv.a.
1922—One 30,000-kw. 37,500-kv.a.
1925—One 30,000-kw. 37,500-kv.a.

Total present capacity 120,000 kw. (150,000-kv.a.).

The Northeast Power Station is located northeast of the main business district of Kansas City on the low bottom lands which border the Missouri River. As there was initially no practical way of carrying underground cables in ducts across these bottoms, the 13.2-kv. outgoing feeders were carried a distance of one-half to one mile on pole lines with conductors supported on 25-kv. porcelain insulators. Lightning is particularly severe in this district and although the circuits, where they changed from overhead to underground construction, were all protected by oxide-film lightning arresters and some of them also had lightning arresters at the power station end, there were, during the five years from 1920 to 1924 inclusive, a total of six cases where lightning entered the power station over these circuits and damaged equipment in the building. There was also one case of a cable breakdown near the feeder exit bushing and another case where an operator pulled a wrong disconnecting switch near the exit bushing, both of which resulted in practically the same kind and amount of damage as that caused by the lightning.

In the majority of these cases the damage consisted of the breakdown of one or more current transformers followed by an arc which burned one or more feeder reactors and destroyed some of the disconnecting switches, primary and secondary wiring, insulating supports and compartment doors. Each of these cases of trouble caused the temporary loss of a feeder circuit and was accompanied by a momentary drop in voltage. In not one of the eight cases, however, did any of the auxiliary motors drop out of step.

This power station has also had one case of trouble in which the bus bars were directly involved. On August 4, 1922, during a period of reconstruction work, an operator carelessly closed a disconnecting switch on a grounded oil circuit breaker which grounded the *C*-phase of the main bus bars. Three 20,000-kw. units were in service at the time, and the neutral of No. 3 unit was grounded through a 3-ohm resistor.

When the accident occurred, generator No. 3 was tripped out by its balanced relays. The operator then tripped off generators Nos. 1 and 2, thereby shutting down the entire system. A subsequent examination disclosed the following damage: The disconnecting switch, with which the operator established the ground, was burned up. The neutral resistor developed a ground and shunted out 5/7 of the resistance, permitting a current flow calculated at 8800 amp. as against a flow of 2500 amp. had all the resistance been in circuit. This excess current burned out and open-circuited that part of the resistor remaining in circuit. Two jumper connections between coils on the *C* phase of unit No. 3 burned open. Within 12 min. the station was again in operation, and within 30 min. the load was back to normal.

At no time in any one of the three power stations, even under the worst of short circuit conditions, has there been any trouble experienced from the shifting of cables and bus bars, or the breaking of bus bar and insulator supports by the mechanical forces which are usually characteristic of a heavy flow of uncontrolled short circuit current.

Based on the experience given above, the authors feel that short circuits in the largest power stations can be so controlled by a properly designed system of bus reactors that their destructive effects will be confined to the immediate vicinity of the arc. There will be some disturbance in voltage beyond the bus reactors, but in only the most severe cases will this be of sufficient magnitude to cause auxiliary motors to drop out of step. Furthermore, they feel that with properly chosen reactors, it will be possible to tie together power stations and power systems of any magnitude so that a short circuit will be of merely local significance, and will not jeopardize the service of the other parts of the system.

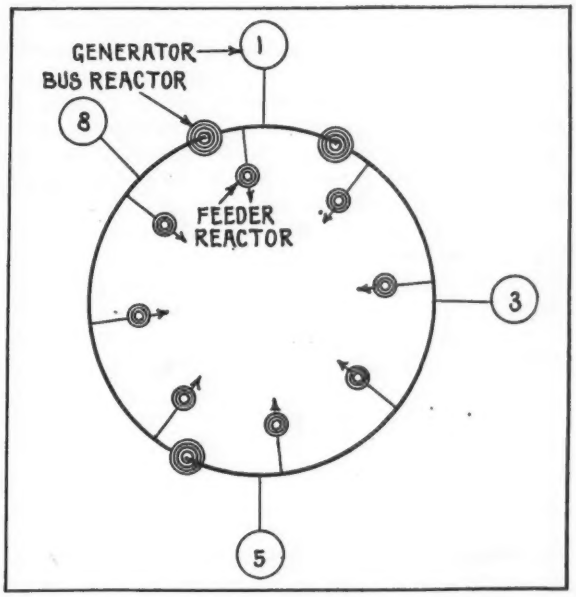


FIG. 3. SIMPLIFIED DIAGRAM OF CONNECTIONS—GENERATORS NOS. 2, 4, 6, AND 7—SHUT DOWN

For assistance in compiling the information on short circuits, the authors expressed their indebtedness to E. H. McFarland of the American Gas & Electric Co., Windsor, W. Va., C. W. DeForest of the Union Gas & Electric Co., Cincinnati, Ohio, and Edwin Jowett of the Kansas City Power & Light Co., Kansas City, Mo.

WHEN WATER IS EVAPORATED into steam in a boiler under constant pressure and temperature, then expanded in either an engine cylinder or turbine nozzles, and then condensed to water in the condenser and the cold condensate pumped back into the boiler we are said to have performed the Rankine cycle. Thus a perfect turbine following the Rankine cycle would convert about 34 per cent of the heat of the steam into work when using saturated steam between the limits of 300-lb. ga. pressure and a 29-in. vacuum. The remaining 66 per cent of the heat would be lost in the condenser circulating water.

DOUBLING the diameter of a pipe increases its capacity four times. Friction of liquids in pipes increases as the square of the velocity.

Good Ventilation Improves Generator Operation

EFFECTS OF DIRTY AIR, CALCULATION OF AIR NEEDED FOR VENTILATION, INSTALLATION OF DUCTS AND USE OF AIR WASHERS. BY CLAUDE C. BROWN

PROPER VENTILATION of electrical generators is an important and essential feature in the design and operation of such apparatus. The modern steam turbo-generator is so designed that in order for it to carry its rated load, the temperature in the armature and field windings must not be allowed to exceed a given maximum figure. This temperature must be well below the critical temperature of the generator insulation. For a given load, the temperature of the generator will be a fixed amount above the temperature of the ingoing ventilating air, hence it is evident that in order to insure continuous and satisfactory operation at name plate rating and at times of overload, an ample volume of clean, cool air should be supplied to the ventilating system of the unit. Within limits, the cooler the air delivered to the generator, the greater will be its capacity. Figure 1 shows the relation between generator load and temperature of entering ventilating air that must be maintained to keep the temperature of the generator within the standard allowable temperature rise of 25 deg.

Ill effects of extremely high temperatures in generator field and armature windings are many and far reaching. In the first place high temperatures seriously impair the insulating properties of the insulation of the windings and cause it to become brittle, carbonized and cracked. Experience has shown that the insulating qualities of material used in generator construction are materially decreased by being continuously subjected to high temperatures. Tests made by Skinner on a 5000-kw., 11,000-v. generator showed that when the temperature of the armature and field windings was increased from 21 deg. C. to 31 deg. C., the power loss in the winding insulation was increased 50 per cent.

Again, in all electrical apparatus there are resistance and reactance losses in which the electrical energy is transformed into heat and dissipated in the latter form. The magnitude of these losses is dependent upon the size and character of the load. In the case of three-phase generators, the heat losses are increased by any of the following conditions: (1) increase in load; (2) decrease in power factor; (3) unbalancing of phases, causing serious inductive currents within the windings of the generator itself. The more efficiently and the more quickly this heat is carried away, the greater will be the load at which any piece of apparatus may be operated without undue temperature rise and without danger or injury to the insulation of the windings.

High temperatures in the generator windings produced by improper and inadequate ventilation are transmitted through the machine framework and through the rotor shaft to the bearings, where they increase the temperature of the lubricating oil, thereby tending to oxidize it and break down the oil film which is so necessary to the proper lubrication of the bearings. This oxidization of the lubricating oil in the lubricating system produces deposits in the bearings that in turn tend to heat the bearings, further increasing the temperature of the unit and producing serious lubricating difficulties. Such conduction of heat through the framework and shaft is, of course,

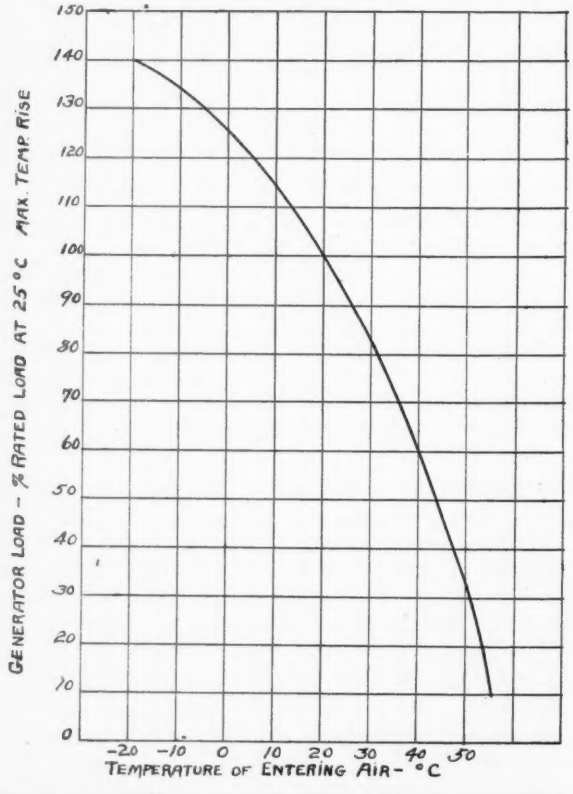


FIG. 1. WITH 25 DEG. C. MAXIMUM ALLOWABLE TEMPERATURE RISE, GENERATOR LOAD VARIES WITH TEMPERATURE OF VENTILATING AIR AS SHOWN BY THE ABOVE CURVE

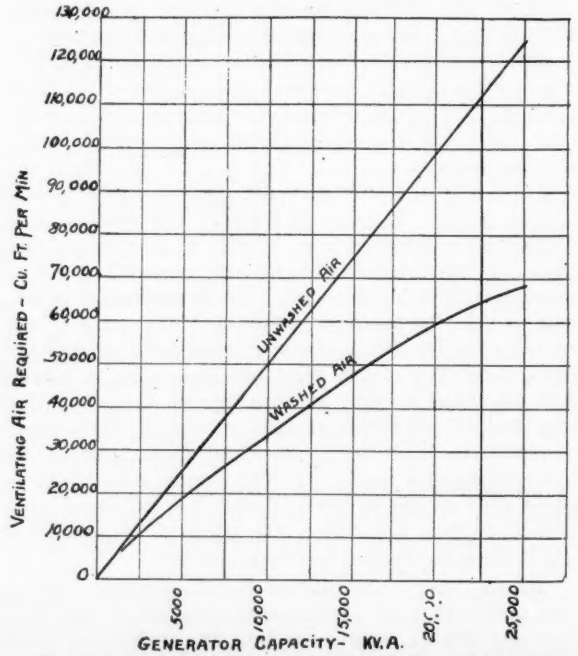


FIG. 2. AMOUNT OF WASHED AND UNWASHED AIR REQUIRED FOR GENERATORS OF VARIOUS CAPACITIES

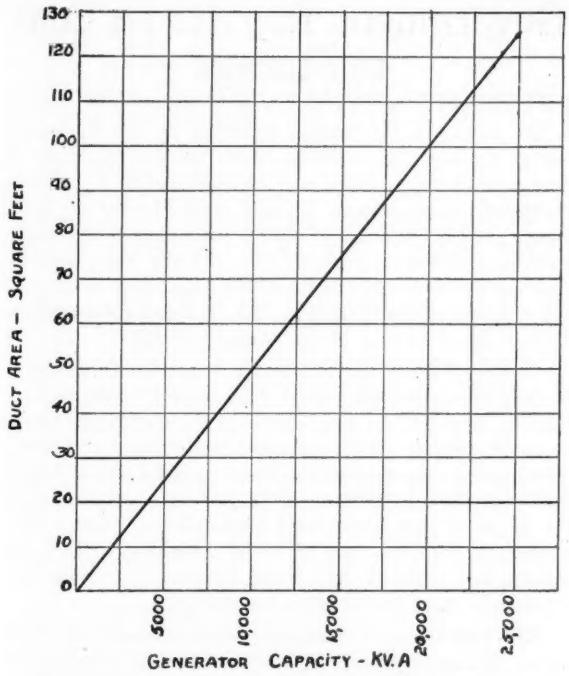


FIG. 3. AREA OF DUCT FOR INCOMING VENTILATING AIR VARIES DIRECTLY WITH GENERATOR CAPACITY

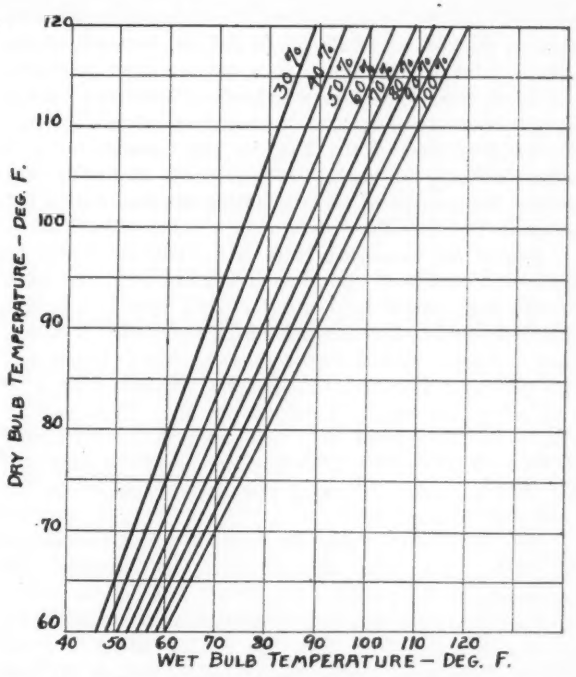


FIG. 4. CURVES SHOWING RELATION BETWEEN DRY BULB AND WET BULB TEMPERATURES FOR VARIOUS RELATIVE HUMIDITIES

non-preventable. As a matter of fact, this heat actually comprises but a small proportion of the total heat of the generator itself.

There is, however, another source of heat, the magnitude of which is not generally appreciated; that is the heat generated by means of the induced current in the generator shaft. The effect of this induced current is detrimental to the operation of the unit, first, because of the rise in temperature that is thereby caused in the shaft and, second, because the passage of the current from the shaft through the machine bearings tends further to oxidize the lubricating oil and break down the oil film in the bearings.

Dirt in Ventilating Air Reduces Cooling Effect

Another equally important feature is that of the cleanliness of the ventilating air, and unless the proper equipment is provided to eliminate the dust and soot from the air, an accumulation of dirt will soon be deposited within the generator which will greatly reduce the cooling effect of the ventilating air. Oily vapors that exist in the air taken from the inside of power plants make such accumulations in the air passages of the generator frame particularly rapid. Most power house air is laden with oil, coal dust and soot, and, although invisible, the dirt lodges and accumulates in the windings and the ventilating spaces of the generator, inviting high temperature and deterioration of insulation. Dirty air, therefore, means excessive heat, which not only increases the ohmic resistance of the various windings and cuts down the capacity of the unit, but shortens the life of the insulation, causing field grounds and possibly burnouts unless the generator is taken apart and thoroughly cleaned at frequent intervals.

Examination should be made frequently to see that neither oil nor dirt is being sucked into the machine and deposited on the windings or in the ventilating spaces. Dry dirt can usually be blown out with compressed air, but if it is found that oil is being accumulated it is advisable to clean with gasolene or benzene. A clean varnish brush will be found to be useful for cleaning between the windings. Vacuum cleaning, however, will insure the best results, particularly where dry dirt is present.

For the proper ventilation of generators, the requisite volume of air averages five cubic feet per minute per kilowatt capacity of the unit and it is advisable to use about 5 sq. ft. of duct area per thousand kilowatts of capacity. The foregoing applies to unwashed clean air of average temperature. Figure 2 illustrates the amount of unwashed, cool, clean air that is required for the proper ventilation of units of various capacities and the same data as applied to washed air that has been passed through an air washer. Figure 3 shows the necessary duct area for units of various sizes.

Revolving fields of modern generators are designed with sufficient blower action to draw in the requisite amount of ventilating air for guaranteed conditions, therefore the unit should be placed in the station in such a position as to avoid undue proximity of the generator to steam or exhaust lines. In case it is necessary to run such lines near the generator, they should be thoroughly lagged and insulated so that the air in the neighborhood of the ventilating duct intake may be as cool as possible.

Where arrangements for cleaning the air have not been provided, the ventilating air should be drawn from the coolest and cleanest source available. It is well to place the intake of the ventilating duct against the wall of the building, extending the duct up for a distance of 10 or 15 ft. in order to avoid the surface dust. The upper or intake end should be open to the outside atmosphere and should terminate in a return bend so that rain and

snow will not fall into the duct. Care should be taken to see that the volume of air is not reduced by short bends, uneven interior, too small a cross section or excessive length of duct. The intake ends of all ventilating ducts should be screened against the entrance of birds, loose pieces of paper and the like, by the installation of a screen with ½-in. mesh. A finer mesh than this will impede the passage of the ventilating air and should not be used.

Heated air exhausted from the generator should be conducted outside the building well away from the inlet. Should it be needed for heating in cold weather, a bypass with suitable two-way damper can be provided. However, such a damper should always be so arranged that it will fall open and thus insure against the unintentional shutting off of the supply of ventilating air. Numerous instances have occurred in which dampers in ventilating ducts have fallen shut, thereby shutting off the supply of air with a consequent rapid rise in temperature in the unit and burning out.

Preferably, all air used for generator ventilation should be filtered or washed before entering the machine. By washing, the temperature of the air can be reduced to approximately the wet bulb temperature and, particularly when the humidity is low, the cooling effect is great. Figure 4 shows wet bulb temperatures for various dry bulb temperatures and relative humidities with the barometer at 30 in.

Some idea of the amount of dirt that passes into the ventilating duct of a large generator may be had from the following:

A generator of 22,500-kv.a. capacity is equipped with an air washer which handles 65,000 cu. ft. of ventilating air per minute. This amount of air weighs approximately 2½ T., so that within a period of three-quarters of an hour the weight of air passing through the generator is equal to the weight of the generator. At the rate of 65,000 cu. ft. of air per minute, a total of 93,600,000 cu. ft. will pass through in 24 hr. As an average, one one-hundred-millionth of the volume of this air consists of dust, dirt and other foreign particles of matter. This is equivalent to the passage of 0.936 cu. ft. of dirt in a period of 24 hr. or a total of 86 cu. ft. of dirt in three months of continuous operation. Most of this foreign matter will, of course, pass through the machine, but a portion of it will lodge in the windings and ventilating ducts unless it is removed from the entering air by washing. This is particularly true when oil vapors are entering with the air.

Resultant cooling of the ventilating air due to its passing through an air washer is appreciable and shows a decided increase in capacity of the unit served. In one case that was investigated, with the atmospheric temperature at 90 deg. F. and a relative humidity of 45 per cent, the generator could be loaded only to 87 per cent of its full load rating, in order not to exceed the maximum allowable temperature rise. When the ventilating air was passed through an efficient air washer, its temperature was reduced to 74 deg. F. and the generator was able to carry 102½ per cent of its rated load, thereby effecting an increase in capacity of 15 per cent.

THE RANGE OF expansion that a U bend expansion joint will effectively take care of, may be doubled if at the time of installation, the bend is sprung open an amount equal to the expected expansive travel.

Government Reports on Coal in Storage

INVENTORY OF THE stocks of bituminous coal in the hands of consumers conducted by the Geological Survey revealed the following facts: the total quantity in storage on June 1, 1925, was 38,000,000 net T., against 44,000,000 T. on March 1, 1925, and 51,000,000 T. on June 1, 1924; the trend of stocks has been steadily downward since the early part of 1924 and the heavy reserves built up by consumers in late 1923 have been reduced to more normal proportions; in fact, the present supply is slightly less than that in the summer of 1921.

Measured in tons, there was a reduction in stocks of 19 per cent during the period September 1, 1924, to June 1, 1925, of which 14 per cent occurred during the last 3 mo. At the rate of consumption prevailing from March 1 to June 1, the stocks on June 1 would last 32 days if evenly divided, a decrease of 29 per cent compared with the 45 days' supply on hand September 1, 1924. It is a well known fact that in every community there are many who habitually carry small or even no reserves and others who carry stocks above the average.

Liquidation of the near-record bituminous coal reserves of January 1, 1924, has now gone on steadily for a year and a half and the total stocks on June 1 were lower than any on record for a normal corresponding date. The reserves on that date were not quite twice those of June 1, 1920, when an acute shortage resulted in a panicky market with runaway prices. Compared with other corresponding dates, the stocks on June 1, 1925, were 25 per cent less than on June 1, 1924, 10 per cent less than on June 1, 1923, and they were 4 per cent less than on April 1, 1921, two months earlier in the season.

Reports from consumers, supplemented by information from other sources, indicate that the rate of soft coal consumption, including exports, from March 1 to May 31, 1925, was at the rate of approximately 1,250,000 T. a day, or 8,750,000 T. per 7-day week. During the preceding 6 mo., September 1, 1924, to March 1, 1925, the average daily rate of consumption was about 1,480,000 T. In addition to the quantity in the storage piles of consumers and dealers, it is estimated that the following quantities were in transit on June 1: on the commercial docks of Lakes Superior and Michigan, 3,800,000 T.; in storage at the mines or at intermediate points, 150,000 T.

Storage of soft coal at the mines is practiced by a comparatively few producers but the tonnage so stored may at times be considerable. Reports from an incomplete list of producers equipped to store show that the total held on June 1, 1925, was barely 150,000 net T. On June 1, 1924, the same companies reported 370,000 T. and in the spring of 1923, more than 300,000 T. The total quantity of unbilled coal in cars at the mines on June 1, was about 800,000 T., a decrease of 200,000 T. from the figure for March 1.

Unlike bituminous coal, large quantities of anthracite are stored at the mines or at intermediate points en route to consuming centers. The supplies at such storage yards were exhausted by the urgent demand for anthracite that followed the strike of 1922. Unfortunately it has been impossible for the Government to obtain complete information on this important subject, and accurate totals cannot be given. The data available indicate that during 1923

no domestic sizes were stored and reserves of steam sizes did not reach the pre-strike level. Beginning early in 1924, the producers began to stock small quantities of domestic sizes and by the end of the year the quantity held in storage appears to have reached or passed the level of 1921. The latest complete information available is that for November 1, 1921, which showed a total in producers' storage piles of 4,488,000 gross T., of which 1,768,000 T. were domestic sizes including pea and 2,720,000 T. were steam sizes. Additions have been made to storage during 1925 and it seems evident that the tonnage on June 1 was somewhat in excess of that on November 1, 1921.

Retail dealers in anthracite had a 52 days' supply of that fuel on June 1, an increase of 11 per cent over the supply on March 1 and slightly more than that on June 1, 1924. The movement of anthracite in the lake trade began early this season and as a result the total on the upper lake docks now stands close to 1,000,000 T. This is more than double the quantity on the corresponding date a year ago.

Parallel Operation of Hydro and Steam Plants

PROPER DIVISION OF PLANT LOADS FOR ECONOMY AND METHODS OF OPERATION DETERMINE POWER COSTS. BY F. A. ALLNER*

SUCCESSFUL parallel operation of hydro and steam plants, so far as it refers merely to maintaining synchronism under normal conditions and through the usual abnormal occurrences, presents no particular difficulties.

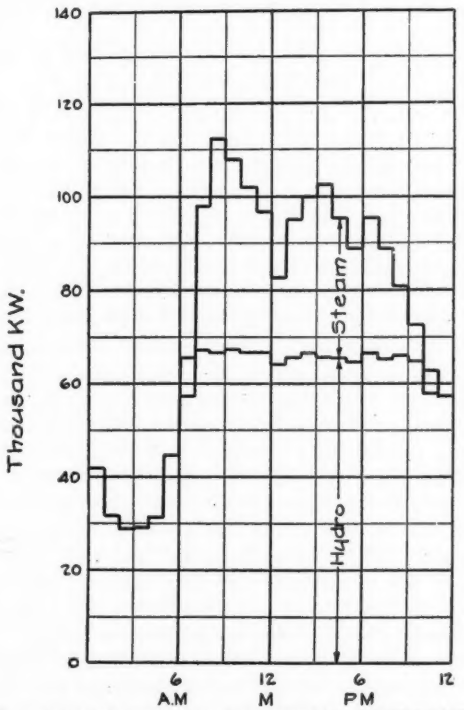


FIG. 1. LOAD CONDITIONS ON TYPICAL HIGH-FLOW DAY, WHEN HYDRO PLANT CARRIES BASE LOAD OF SYSTEM

In order, however, to obtain the most favorable economic results and the best possible service conditions under certain existing or well-anticipated limitations, a number of seemingly subordinate features should be given careful attention.

Few undeveloped water-power sites within practical transmission distance from the important load centers of the eastern states are so favorably endowed by nature that power from such plants can be delivered to the city networks at a cost materially lower than that of steam power produced locally at modern large-capacity plants. The efficiency of prime-mover and fuel-burning equipment has shown a distinct upward trend in recent years, accompanied by a general lowering of fuel prices; however, economic comparison with hydro power cannot be set down once for all in definite figures, as the various elements making up the cost of steam power are subject to changes that cannot be forecast with any degree of accuracy except for an extremely short span of useful service life.

The maximum in energy output will be reached when the hydro plant can operate continuously with wide-open turbine gates throughout the excess-flow period. The maximum of peak service can be secured from the hydro plant when the system load has grown to a point where the entire hydro generating capacity can be utilized on peak generation under minimum-flow conditions, saving then the equivalent amount of effective steam capacity in the carrying of system loads.

LOW-FLOW OPERATION FOR MAXIMUM HYDRO PEAK SERVICE

In order to derive the greatest saving in investment for steam capacity from parallel operation with a hydro plant, it is necessary, first, to determine the load conditions which will require the greatest steam output. These will depend on the character of the seasonal variations of system load, on variations in flow as obtained from reliable records covering a long period of years, on the extent of available storage facilities, on seasonal limitations on the effective capacity of a given steam plant due to amount and temperature of circulating water and so on. As a rule, it will be found that even for run-of-river developments with only daily or week-end storage, the greatest saving in capacity investment is rendered by the hydro plant on days of maximum annual peak, which should then be assumed to coincide with the day of lowest winter flow on record.

Figure 1 shows typical high-flow conditions and Fig. 2 low-flow conditions, both being plotted from actual load data on representative days. The loads are drawn in as one-hour integrations, taken on the hour.

On the critical low-flow peak day the output of the hydro plant, expressed as kilowatt-hours delivered per cubic foot per hour of available river flow, will be slightly reduced by reason of the extremely low load-factor generation as compared with the delivered output when operating at a high load factor. Thus it will be found advantageous to operate most run-of-river hydro plants during the low-flow period in a manner that will give highest load-factor generation to the steam plant, to which will be assigned the base load. In the example illustrated in Fig. 2 this method of dividing the genera-

* Abstract of a paper read at the Spring meeting of the A.S.M.E. at Milwaukee, Wis., May 18 to 21, 1925.

tion has been carried out even to the extent of stopping hydro output entirely during the off-peak hours and operating one or two units as synchronous condensers, the power for driving them being supplied by the steam plant.

There were a number of reasons for this method of off-peak condenser operation: first, the desire to let the steam plant operate even during the off-peak hours at best efficiency, which generally means the loading of steam turbines at near maximum output and to have the hydro units come in automatically as spares on unexpected load swings or in the event of failure of a steam unit; second, to assist the steam units in the carrying of wattless current which otherwise might require the paralleling of another steam unit, with a consequent lowering of steam efficiency; third, to protect the service of the hydro company's other customers as to capacity and also as to better selective relay action in the event of high-tension-line disturbances; fourth, to relieve the steam plant of the voltage-regulating task for the other high-tension-line services, which can be better taken care of by field adjustments on the hydro generator operating as a synchronous condenser.

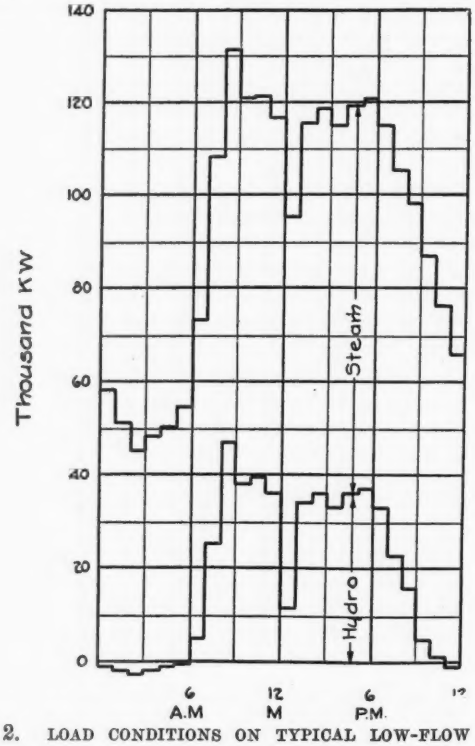


FIG. 2. LOAD CONDITIONS ON TYPICAL LOW-FLOW DAY, WHEN STEAM PLANT CARRIES BASE LOAD

High-Flow Operation for Maximum Hydro Energy Output

During the period of excess flow, the hydro plant should be operated for maximum energy output, i. e., with the hydro plant carrying the base portion of the system load, and the steam plant the remainder. It will be noted from the load and generating curves of Fig. 1 that the maximum hydro-output idea has not been carried out to the point of theoretical perfection. For conditions of less than 100 per cent utilization factor at the hydro-plant, there will be at least two—and possibly three more—periods when an increase of hydro output seems theoretically possible.

During the first period, that is, near the intersection of the ascending branch of the morning peak with the hydro capacity line, the fires must be brought up rapidly and several steam units must be paralleled in quick succession in order to be sure of carrying the rapidly increasing industrial and railway load. Naturally, the steam operator prefers to be on the safe side, having his boilers and prime movers on the line rather a little earlier than too late; he also prefers to have his units carry a certain percentage of rated capacity from the very start, as he wants to avoid just floating the unit in without load and having it motored partly during momentary downward swings of the load, unless the units are specially equipped to stand motoring.

During the period of the load recess around the noon hour, an intersection again may take place between the downward branch of the morning load with the hydro capacity line, followed about half an hour or so later by another intersection of the ascending branch of the p. m. load curve.

During the third period, the intersection of the descending branch of the p. m. load curve with the hydro capacity line, the drop in load during the greater part of the year is generally not as rapid as the rise of the a. m. load or the changes during the noon recess. The time of intersection, however, is more apt to shift from one weekday to another, and the operators have to be fully as watchful during that period as on the other occasions to avoid unnecessary loss of hydro output.

Frequency Indication Signaling Aids Load Division

Load division during these various load-intersecting periods, as discussed above, was greatly improved on the system from which the illustrations are drawn after a load-signalling scheme by frequency indication had been adopted. Under that scheme the hydro governors were set to maintain approximately one-half of one per cent above normal frequency whenever the plant was not fully loaded, that is, when the hydro governors maintained the frequency. When the hydro plant was wide open, that is, when the steam governors were maintaining the frequency, the latter were so adjusted that they maintained a frequency of half of one per cent below normal. Thus, a glance at the frequency indicator advised the steam operator whether or not the hydro plant was fully loaded. If the frequency was above normal, he adjusted the load on the steam units by switchboard control of the synchronizing springs down to the minimum load desired on the steam unit. Conversely, the hydro operator could see from the frequency indication, in case it had dropped to normal or slightly below, that his water wheels were wide open and that his governors had ceased to function. If the frequency was slightly above normal, he knew that the hydro plant had still some capacity to spare, and then advised the steam operator from time to time by telephone, after a glance at his station total-output meter, how much capacity he still had in reserve.

The practical working of this frequency-signaling plan is illustrated in Fig. 3, which is a reproduction of actual hydro output and frequency charts during the a. m. intersecting period of a typical high-flow weekday. The frequency is slightly above normal (25.1 cycles) until about 7:30 a. m., and after the hydro plant is wide open

(7:32 a. m. on the wattmeter chart), the speed is lowered gradually to 25 cycles.

A load system that is served by the combination of a hydro and steam plant may obtain under certain favorable combinations a more perfect service than if it were served by either the hydro or the steam plant exclusively.

High Availability Factor of Hydro Plant Improves Hydro-Steam Operation

Sudden capacity reductions without warning are rather rare at the hydro plant. Statistics recently compiled from an average-service record of large-capacity hydro units showed that the "service demand availability factor" was in excess of 99.5 per cent. It may permit, at times, a substantial saving of investment for spare prime-mover capacity when a system is served by mixed hydro-steam supply.

It is not considered safe practice to bring up a large steam unit from standstill to full load in much less than one hour. A hydro unit of nearly equal capacity can be brought up to full load from standstill in less than one minute. Thus, the feeling of security as to carrying of the system load is greatest when one or more hydro units are held in reserve, which is the usual low-flow condition.

Nearly all the capacity reductions at the hydro plant approach rather gradually, permitting sufficient advance warning to call in additional steam capacity early enough to protect the system load. During the entire low-flow period and occasionally during the off-peak hours in high flow, when, for some reason or other, a small part of the system load is supplied by steam, the hydro plant will generally be able to make up such capacity shortage by speedy paralleling of hydro units, before its disturbing effect is felt by loss in frequency requiring cutting off of load.

Hydro-Steam Parallel Operation Affects Average Cost of Steam Generation

Frequently the question is asked whether a steam plant, when operating in parallel with a hydro plant in supplying a given system load, could be expected to show a lower operating and maintenance cost per kilowatt-hour than if the system load were supplied exclusively by the steam plant. There are no actual cost figures available from any installations of appreciable size, say 50,000 kw. or over, which cover identical conditions for a sufficient length of time to permit setting up reliable cost figures that are strictly comparable for the two operating conditions.

There is little doubt, that the average steam cost per kw-hr. would be higher in the case of mixed supply when the hydro plant is an all-year-round steady source of power, supplying the base portion of the system load. Inversely, the kw-hr. cost of the steam portion of the mixed supply will assuredly be lower than for all-steam supply in case a hydro plant that is equipped with seasonal storage furnishes the peak portion of the system load through the greater part of the year.

In the case of a run-of-river developments, the overall result will probably be controlled by the weighted preponderance of the higher or lower load-factor generation compared with the load factor of the total system load. A steam station operating in parallel with a run-of-river hydro plant is subject to considerable variations of operating conditions in the course of the year and, at times, also to sudden changes from one day to the next.

If the regular seasonal high-flow period occurs with a fair degree of certainty for several consecutive months each year, the mixed supply will offer to the steam plant an opportunity of carrying on major repair work and routine overhauling in an efficient prearranged manner.

A still further going advantage in the conduct of maintenance work can be realized when the hydro and steam plants are located in close enough proximity to permit the utilization of the same maintenance force and, partly also, of joint shop facilities for the routine overhauling work of both plants.

Again, during the low-flow season the combined maintenance force can be chiefly engaged on the work at the

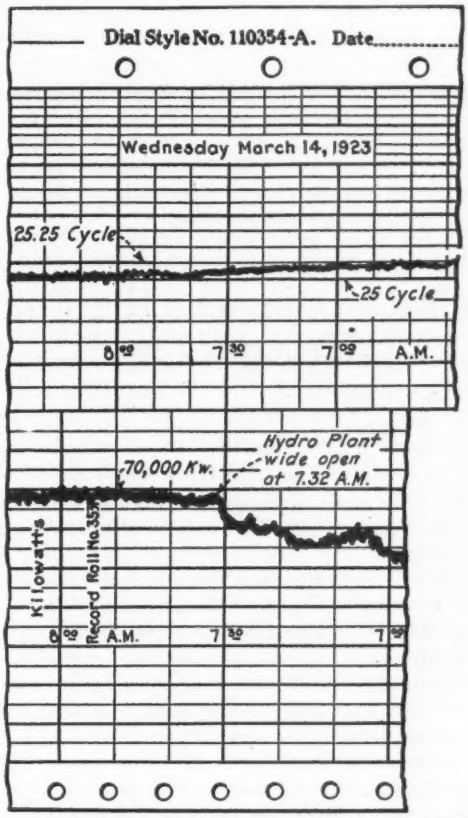


FIG. 3. FREQUENCY AND WATTMETER CHARTS ON TYPICAL HIGH-FLOW DAY, ILLUSTRATING LOAD-SIGNALING SYSTEM BY CHANGE OF FREQUENCY

hydro plant, as this is the time when all available steam equipment may be called on for maximum output, while hydro equipment can be taken out of service without loss of output.

Ideal Conditions for Combined Hydro-Steam Operation When Steam Plant Is Immediately Adjacent to Hydro Station

A steam station immediately adjacent to a run-of-river hydro plant of 150,000 hp. rated capacity is now under construction in southeastern Pennsylvania. The initial installation will consist of two 12,500-kv.a. steam turbines. These first two and all the future generating units will be connected directly to the low-tension bus of the adjoining hydro station and will be operated from the same control board. An unusual opportunity will be had at this installation to utilize the previously mentioned di-

versity in the time of steam and hydro maintenance work. From the steam point of view a rather favorable layout is offered at that station for the arrangement of conduits for the circulating water, which is drawn from the forebay of the hydro plant and returned there. This is expected to reduce materially the danger from frazil-ice attacks, at least to the group of hydro units where the intakes are located near the outlet of discharge conduits.

Bearing on the subject of hydro-steam parallel operation, an effort has been made at this plant to obtain for the first two units the shortest possible starting time, to permit their being floated in at no load and also to permit motoring from the hydro plant for short periods in every-day high-flow operation. The governors are designed for exceedingly short traversing time and will permit adjustment of regulation and of range from the control board while running. By this arrangement a better control will be obtained for any desired division of load as between hydro and steam units and also in regard to the steam units at other stations. These features will greatly assist in obtaining the maximum theroetically possible hydro output during the high-flow period.

Grate Doings at the First African Church

RRRR-r-r-r-r-ring!

"Hello!"

"Hello! Am dis da Gen'ral Grate Co.?"

"Yes, this is the General Grate Corporation."

"Well, ah wants t' talk t' da genl'men whut selled us dem grates fo' da Fust African Methodist Chuch up'n fo'ty fust street las' fall."

"Oh yes, I remember. You mean the shaking grates which we installed in the heating plant of your church, is that it? What's wrong with them now?"

"Well boss, dem grates am no good fer nothin' an' all da temants am kickin' 'cuz no heat cums outen da pipes. No sir, boss, dem grates is jes plum no good an' da Rev. Jackson says we aint gwine t' pay fo' em. He says fo' yo all t' make em burn."

"Well now, Sam, I am sorry to hear that, but don't get so excited. We have been down to your plant several times and each time have found nothing wrong with our grates. However, we'll send another man down to see whether we can't straighten this thing out."

The assistant sales manager of the General Grate Corporation smiled as he hung up the receiver and turned to his visitor, the conversation with whom had been interrupted by the telephone call.

"I thought we'd had enough trouble with that outfit," he remarked. "This is about a small installation we put in, in the heating plant of a colored church uptown. This church is comparatively wealthy and owns approximately a square block of colored tenements in the immediate vicinity, which together with the church are heated by a small central heating plant. The occupants of these tenements number among the most exclusive of the darktown 'four hundred,' and being of discriminating dispositions, are somewhat of a nuisance, at least so Sam thinks, when it comes to the question of heat.

"Sam, a sort of major domo who serves in the joint capacity of janitor and sexton, naturally has to bear the brunt of the 'kicks' and were he a man of less confidence in his ability to keep the tenants in submission, he would have resigned his position long ago."

"How did you come to sell grates to an outfit of that kind," asked he visitor, smiling.

"Well," explained the A. S. M., "Sam walked into the office, here, a few months ago with one of our catalogs in his hand and without any preliminaries, proceeded to order a set of our latest type of shaking grates for his boilers. That was the first time we had anything to do with them. Since the grates were installed, however, we have had no end of complaints, but in each case we found nothing wrong with the grates. The first time we were up there, we found that the boilers had never been cleaned since their installation and found them so filled with soot that it is a marvel how any of the gases got through.

"Well, they cleaned the boilers out, but still they could get no results. Then we discovered that the breeching to the stack was so corroded that it was impossible to secure any draft. So they repaired the breeching and we thought we were through with them, but it seems we were mistaken."

"Must be amusing," commented the visitor.

"Amusing! Yes, if there was any indication that it would come to an end. I'll tell you what; I'm going down that way in the morning and will drop in myself. If you have an hour to spare, come with me, and we'll see what the latest difficulty is."

* * * *

When the assistant sales manager and his friend proceeded down the narrow passageway leading to the heating plant of The First African Methodist Church the following morning, there issued from the far end of the passage a series of deep sonorous rumblings, not unlike the roar of a wild animal.

"Must keep a couple of lions down here in the basement," he remarked to the friend. "Better watch out."

When they entered the boiler room, however, they found no wild animals, in fact, the room apparently was devoid of human occupancy. Opposite the two boilers in one corner of the room, was a crudely constructed coal bin, while the center of the room was strewn with ashes and partly consumed coal. It appeared as though somebody had drawn all the coal from the furnaces out upon the floor. The steam gage on the boiler was down to zero and upon opening one of the furnace doors, no evidence of fire could be discovered, although the grates were piled high with coal. Sam was nowhere to be found.

The rumbling noise which had attracted the visitors' attention when they entered had by this time altered in character and had degenerated into an intermittent wheeze. It sounded like a reciprocating pump in distress. As it seemed to issue from the rear of the boilers, the two men squeezed their way between the narrow aisle between the boiler and the wall to the rear of the room, but found neither wild animal nor pump. Instead, they found a gorgeously colored couch upon which reposed a corpulent darky in deep slumber, who proved to be the source of the stentorian wheeze which led to his discovery.

"Here's the real reason why our grates won't function," said the A. S. M., grasping the slumbering Sam by the shoulders and shaking him vigorously.

"Wake up, Sam!" he shouted.

"Yessuh, yessuh, I's 'wake," sputtered that bewildered individual, staggering to his feet. "Gee, golly, boss, yo'

sho' done scared me dat time. Ah figgered da boilers had done gone an' blowed up."

"Not much danger of that when you use the furnaces for coal storage bins. What's the big idea of stuffing them so full of coal that no air can get to the fuel?"

"Yo' mean me, boss?" inquired the still half-dormant Sam.

"Of course I do; who else fires the furnaces around here besides you? Just look at this furnace; it's packed tight with coal. How do you ever expect to make steam that way? Don't you know any better than that?"

"Well, boss, if ah puts in a little bit o' coal, ah don't gits any sleep."

"Sleep! What do you mean?"

"Well yo' sees, boss, it's dis way. Ah needs a powe'full lots o' sleep an' ah gits me a couch so ah kin git some sleep in 'tween firin' times. Ah fires an' den ah sleeps. If'n ah puts in lots o' coal ah sleeps long. If'n ah puts in little, da fire goes out too soon and ah don't sleep. So ah puts in lots."

"Yes, I see you do. A desirable arrangement, no doubt, Sam, and as far as I'm concerned you are at perfect liberty to pursue it; but don't you ever dare to call us up again and have the nerve to tell us that our grates are no good, for if you do, the Rev. Jackson is going to hear about this. Do you understand?"

"Yessuh, boss, yessuh, ah gits yuh. Ah keeps da fires burnin' frum now on; but, boss, don't tell Rev. Jackson about dis couch, 'cuz it use t' belong t' him an' he don' know ah's got it."

Growth and Influence of Mechanical Power*

POWER EQUIVALENT FOR EACH INHABITANT OF THE UNITED STATES IS THAT OF ABOUT FIFTY SLAVES. BY WM. L. DE BAUFRE

DURING THE 50 yr. from 1869 to 1919, remarkable increases occurred in the horsepower available in prime movers. There have been further advances since that date but the following approximate figures based partly on the census data for 1919, will give some idea of the tremendous amount of mechanical power now at the service of mankind. In manufacturing, the 2,300,000 hp. of 1869 has grown to more than 29,500,000. In mining and quarrying, the 111,000 hp. has increased to over 6,800,000. On the railroads, the horsepower has increased from 3,300,000 to 65,000,000 or more. The estimated horsepower of the United States Navy is about 10,000,000 and commercial shipping, private yachts and motor boats will account for another 10,000,000 hp. On the farms, animal power only was used in 1869, amounting to less than 10,000,000 hp.; in 1919, while the animal power had more than doubled, mechanical power to the extent of about 20,000,000 hp. was employed. Probably 4,000,000 hp. are installed in isolated plants in non-industrial establishments. In 1869, central power stations did not exist for furnishing electricity for lighting, power and railways; in 1919 they had an installed capacity of 20,000,000 hp. of which about 10,000,000, used in industrial plants and on farms, is included in preceding figures. Conservatively, 345,000,000 hp. in internal combustion engines are installed in the 17,000,000 automobiles, motor trucks and tractors in use in this country, of which about 6,000,000 hp. is already accounted for as employed in agriculture.

The grand total of these figures is over 500,000,000 hp. available for a population of 105,000,000 people, or about 5 hp. for each man, woman and child. Since a man's power is less than one-tenth of a horsepower, this is equivalent to more than 50 slaves for each inhabitant of the United States.

POTENTIAL WATER POWER CANNOT MEET DEMANDS

Of the 500,000,000 hp. available in 1919, about 8,000,000, or less than 2 per cent, was water power. The remainder had for its primary source of energy, coal, petroleum or natural gas, except about one-tenth of one per cent in wind mills on farms. The United States Geological Survey has estimated that the amounts of energy contributed by the four main sources of energy in the United States in 1919, were in the following proportions: coal, 77.3 per cent; petroleum, 13.6 per cent; natural gas, 4.3 per cent; water power, 4.8 per cent. The potential water power resources of the United States even with water storage are estimated by the United States Geological Survey to be only 34,818,000 hp., or less than one-fourteenth of our present installed capacity. Evidently, water power can never take over the burden now borne by coal, oil and gas. Unless science and engineering develop wider applications of what are now minor sources of mechanical power, the human race must some day return to work.

Men on the street are inclined to shrug their shoulders and say that the scientists will discover other sources of energy before that time, that the energy of the atom will be unlocked or that electricity will be taken from the air. To a person not well grounded in the physics of energy and matter, such propositions do not appear any more wonderful than, for example, the radio. I regard, however, as improbable the unlocking of stores of energy from sources other than those already used to some extent.

Some research should be devoted to the development of what are now minor sources of mechanical power. The exhaustion, however, of our natural resources of coal, oil and gas is not immediate. Petroleum in quantity will probably be available for 200 or 300 yr. and coal for 2000 or 3000 yr. Greater efforts should be exerted to improve the combustion of fuels, the production of mechanical power from the heat of combustion and the utilization of mechanical power by machinery of various kinds.

BETTER GRADES OF COAL FAST DISAPPEARING

Although coal will be available for many years, the better grades for metallurgical and power purposes are approaching exhaustion. Methods of utilizing the poorer grades must be developed to higher degrees of efficiency. One method of accomplishing this is through reducing the amount of inert nitrogen in the air supplied for combustion. There is thus needed an economical process for producing oxygen which may be mixed with atmospheric air or used in a nearly pure state.

After combustion has taken place, the energy exists as heat and improved means should be sought for converting heat energy into mechanical energy. It has been customary to analyze power plant performance by the first law of

*Abstracted from paper read before Nebraska University Chapter of Sigma Xi, May, 1925.

thermodynamics, but such an analysis should be based upon the second law in order to show where the greatest inefficiencies exist in the process of converting heat into mechanical work. The first law analysis heretofore made is misleading in this respect. For example, according to the first law, no loss whatever results in a steam power plant by heat transfer from the products of combustion in the furnace to the water in the boiler to evaporate it into steam. The second law analysis shows this to be the largest single item of loss in the whole power plant.

Research in utilizing mechanical power is required in order to minimize the expenditure of fuel for the accomplishment of a desired result. While there are a multiplicity of ways of using power, the main item of such research should be friction, for nearly all the energy of mechanical power is finally dissipated as heat in overcoming frictional resistances. This may appear to be a startling statement; yet if you will think of the movement of a railroad train from Lincoln to Chicago through the burning of, say, 30 T. of coal, you will appreciate that the tractive effort of the locomotive is expended entirely in overcoming the frictional resistances encountered by the train against the air and in the bearings.

Economic conditions are bringing about improvements in the production and utilization of mechanical power. For example, the coal consumption per kilowatt-hour produced by electric utilities dropped 25 per cent in the 5 yr. from 1918 to 1923. Also, steam locomotives have been developed which, in comparison with the standard locomotives of but 3 yr. ago, will haul 50 per cent more tonnage for the same amount of coal burned. Until today, coal economy has been of minor importance in railroad operation; however, conditions are changing and scientific analysis is now being applied to the steam locomotive with great improvements in efficiency.

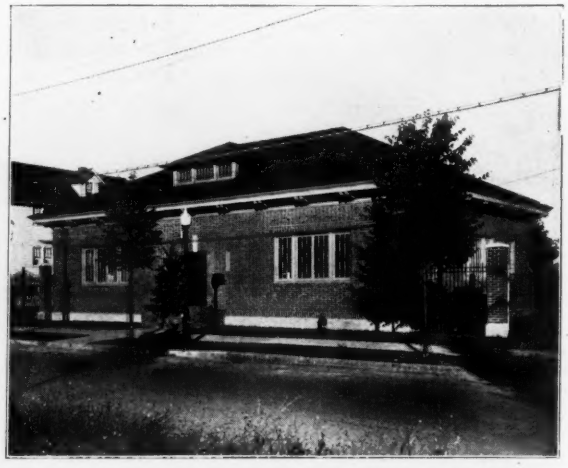
In the 50 yr. from 1869 to 1919, the population of the United States increased 2.76 times. In spite of the shift in population from the country to the city, so that only one-quarter of those in gainful occupations were employed in agriculture in 1919, while nearly one-half were so engaged in 1869, the agricultural production increased 4.94 times, or 80 per cent more rapidly than the population. During the same 50 yr., the products of mines increased 18.81 times or nearly 7 times more rapidly than the population. The manufactured products increased 9.61 times, or about 3.5 times more rapidly than the population. While many factors contributed to these increased outputs, the most important factor is undoubtedly the increased production and utilization of mechanical power by machinery.

Depositing Metallic Chromium Electrolytically

FRENCH PATENT No. 579,243 has been awarded to the Societe Elcrom for an electrolytic method of depositing metallic chromium. The bath is composed of chromic oxide and an acid, in about equal weights, the proportion being maintained by addition of the acid at a constant temperature. The acid may be hydrochloric or acetic, with the addition of an appropriate conducting salt or acid such as boric, tartaric, citric or sulphuric acid, which produces a non-colloidal solution. The current used is from 12.9 to 19.4 amp. per sq. in. at from 2 to 4 v., the temperature of the bath being kept at about 64.4 deg. F. The supplementary acid or salt is used only in small quantities.

Attractive Design for Substation

AN UNUSUALLY attractive substation was recently erected by the Municipal Gas Company at Albany, New York. As may be seen from the photograph, it is of



the bungalow type of construction and harmonizes well with other buildings in the residential section in which it is located. It was designed by Thomas E. Murray, Inc., of New York.

Bituminous Coal for Generating Water Gas

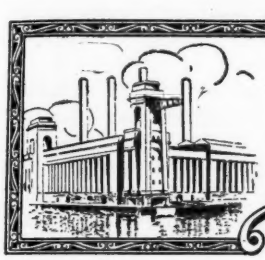
IN A memorandum covering the abstract of Technical Paper 335 by Wm. A. Dunkley, the Bureau of Mines has just announced the success of experiments for producing water gas from low-sulphur bituminous coals of the Middle West. This work was done in co-operation with the Illinois State Geological Survey and the Engineering Experiment Station of the University of Illinois.

Heretofore trouble has been experienced in attempts to use bituminous coal for making water gas so that coke or expensive Eastern coals had to be used. The importance of these results lies in the fact that more coke may be saved for use in industries where bituminous coal cannot be employed to advantage and that transportation of Eastern coals is avoided.

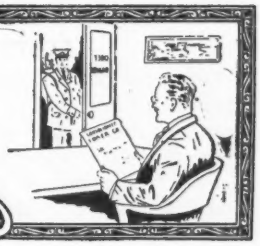
The difference in the market price of coke or anthracite—the commonly used water-gas fuels—and bituminous coal has stimulated the study of methods of using bituminous coal for making water gas.

With small sets results have been promising, but with generators 8 ft. 6 in. or more in diameter they have not been so favorable; the experiences, however, have been instructive. Operators who contemplate using bituminous generator fuel are urged to study this paper for data upon which to base calculations when attempting to estimate whether the use of such fuel would be economically feasible.

THE SYRACUSE LIGHTING CO., INC., Syracuse, N. Y., is selling a block of preferred stock, a portion of the proceeds to be used for extensions and improvements in plants and system, and general financing.

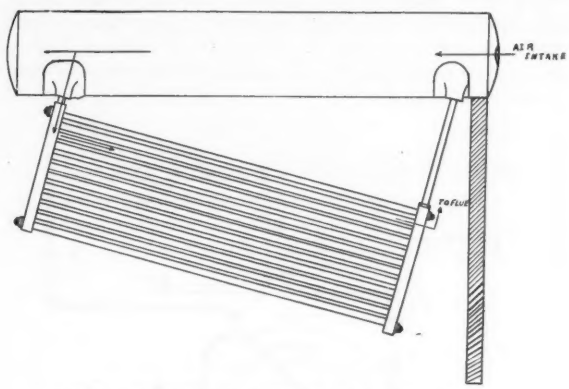


LETTERS DIRECT FROM THE PLANT



Cooling a B. & W. Boiler

A FEW DAYS ago, I was asked by one of our operating engineers to inspect the drums of a 500-hp. B. & W. boiler, which had just been taken off the line after six weeks of severe service. Anyone accustomed to going into the steam drums of such a boiler knows they are fairly hot and that it is not a job which one anticipates with



BOILER COOLED BY AIR FROM DRAFT IN FLUE

pleasure. To my surprise, however, I found a nice current of air passing through the drums and they were quite comfortable to work in.

After examination, I found the repair man and asked him how he made the boiler so nice and cool; here is what he told me.

He had simply taken off a few header caps at the rear end, as shown by the accompanying sketch, placed an old mat over the upper end of the rear vertical tubes, and opened his draft damper slightly. This caused the air to flow in through the manhole along the drums, down through the front vertical tubes, and out through the main tubes, as shown by the arrows.

Wabana, Newfoundland. J. B. PETRIE.

New Developments in Engineering

USERS OF STEAM power should continually bear in mind that the oil engine often has important advantages over the steam engine. The operating cost is practically constant, regardless of the capacity. Whether it is 50-hp. or a 2000-hp. plant, the lubrication, fuel consumption, maintenance cost, and other items, are almost directly proportional to the capacity. This is not the case with steam plants. Seldom is a steam plant more economical than an oil engine plant. Also, now that methods are available for utilizing the hot exhaust from oil engines for generating steam and making hot water for manufacturing processes, the oil engine is invading fields where it was once considered out of place. By utilizing the hot exhaust gases, it is not uncommon to obtain an overall efficiency of 70 per cent. Sometimes combinations of the two are installed, the oil engine being used for generating the power and the steam plant for generating heat and furnishing steam.

It is reported that in Germany a steam boiler has been developed in which the tubes are heated red hot. Oil is used for heating. Atomized water is then injected into the tubes, generating steam instantly. There is no water in the boiler. Consequently, it is claimed that an explosion would not be serious. The water for steam and the oil for burning are both regulated automatically. Other advantages claimed are that the cost of the boiler is much less than the cost of other boilers and that the boiler is more economical in the use of fuel. Whether or not all of these claims will be supported in actual practice remains to be seen.

At the Leipzig Spring Machinery Fair a 15-hp. steam engine was driven by a boiler of this kind at 100 lb. pressure. The boiler was heated and steam generated in 4 min.

To meet the demand for a meter that will measure the amount of coal passing into a furnace over a chain grate stoker, such a device has been developed. This meter is of advantage because it provides a means for checking the total coal consumption of all boilers, as well as the consumption of each boiler in the battery. It enables the fireman to operate the grate at its best speed. It helps the fireman to load all of the boilers evenly at their best efficiency. If coupled with a steam flow meter, it becomes possible to keep a constant watch on the efficiency of the unit or the number of pounds of steam being evaporated per pound of coal during any period of time. This meter is so accurate that the manufacturers guarantee a measuring efficiency of at least 97½ per cent. The writer considers this exceedingly close in view of the fact that coal is not a liquid and that it comes in various sizes of lumps. Many fluid meters are less accurate than 97½ per cent.

Because of the fact that at one time horses developed most of the power used by man, the term "horsepower" is still with us and is one of our units of power measurement. It is assumed that a horse weighing 1200 lb. can develop one horsepower continuously for 8 hr. Therefore, to develop a horsepower continuously would require three horses or 3600 lb.

It is interesting to compare the weight of a horse with the weight of a modern man-made engine. Aeroplane engines have recently been developed in the United States, which, it is claimed, will produce 1 hp. for each 1.02 lb. of engine weight. Until recently the record was 1.3 lb of engine per hp. In other words, we have almost reached the point of developing one continuous hp. for each pound of engine.

Newark, N. J. N. G. NEAR.

Grease Extractor Removes Water from Air Line

OUR ORIGINAL air compressor was small and was only intended for pumping up sprinkler systems. The air demands on this became so great that a larger belt driven compressor was purchased, but the old receiver was not changed. This tank is outside the building and the air intake for the compressor is also on the outside. In warm weather this receiver became quite hot and although blown out twice daily water was carried along in the main supply line of the factory. Besides the small receiver, this condition was aggravated by the fact that even the new compressor was too small and had to be overloaded.

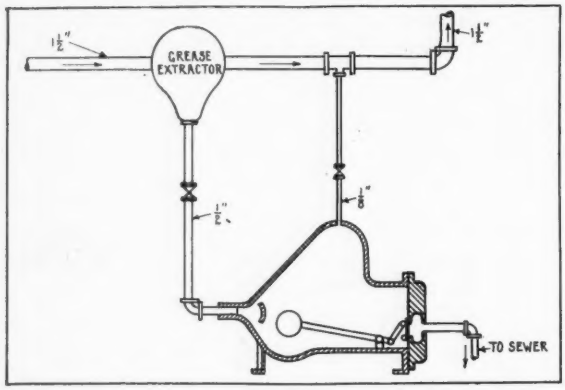


FIG. 1. OLD GREASE EXTRACTOR TO REMOVE WATER FROM AIR LINE

Without consulting the engineering department, the purchasing agent bought a compressor which he was led to believe had a capacity of 250 cu. ft. per min., but which was found to be rated at 56 cu. ft. per min. It was up to the engineer to get dry air. An old grease extractor, that had been used on the exhaust line of a small fan engine, was installed in the discharge line, and the trap connected as shown in Fig. 1. At first the ⅛-in. pipe was connected as shown and good results have been obtained ever since. That was 5 yr. ago. Since then I installed a drain for another man as shown in Fig. 2. No grease extractor could be found, so water pockets were formed by tees in the line. These were joined into a common header and discharged into a trap.

Minneapolis, Minn. F. S. RUTLEDGE.

Evaporation Determined by Simple Means

IT IS OFTEN possible to conduct tests in a power plant without meters or special istruments of any sort and yet obtain fairly accurate results. For instance, it was desired to know the amount of water evaporated per hour in a boiler room where no meter or scales were available. A simple method solved the problem. An ash can which was watertight up to a point 6 in. from the top was taken from the boiler room and connected to the feed pump suction, which necessitated cutting a 2½-in. hole in the bottom and drilling four holes to match a 2½-in. pipe flange. The flange was bolted on with a sheet of ⅛-in. packing and this packing was also used for washers under the heads of the bolts inside the can in order to insure a water-tight joint. The can was filled with water up to the point where the handles were riveted on and the weight of water calculated.

In this particular case the can held 217 lb. of water and as the load was steady it was decided that a test of one hour would give fairly close results. So a pipe was connected from the city water supply to allow filling the can as often as necessary. The feed pump, of the simplex type, supplied a 72-in. return tubular boiler. The water level in the boiler was indicated by tying a string on the gage glass and the feed pump was run at a speed that would hold the water level nearly stationary. When the can was emptied the pump was stopped and started again when the can was filled.

It was necessary to fill the can 21 times during the test and this required the undivided attention of one man, since the can was filled and emptied every 3 min. It had previously been ascertained that the pump valves were tight and no leakage existed at any point which would allow water to go anywhere except to the boiler. Also the blowoff valve and waste pipe from water column

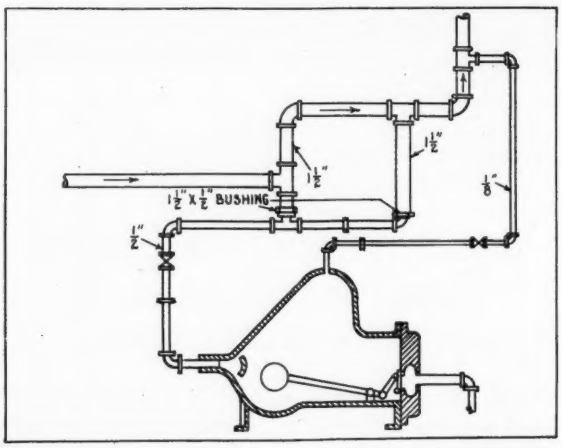


FIG. 2. TEES IN AIR LINE SERVE TO DRAIN OFF CONDENSATE

were known to be in good condition. It was comparatively simple then to calculate the evaporation, which was 4557 lb. of water per hour. The water level was the same at the beginning and end of the test.

The pump was never started until the filling valve was closed and always stopped before the water was pumped lower than the flange connection at the bottom of the can, since the volume of water in the suction pipe was always enough to keep the pump primed. The task would have been rather tedious if the test was run all day, but a modification of this plan was used in a larger plant to accomplish the same purpose.

Here the ash can was connected to the feed pump in the same manner and filled with water. While it was being pumped dry the strokes of the pump were counted and by dividing the weight of water in the can by the number of strokes the amount of water per stroke was determined. Also this method gives the percentage of slip in the pump fairly accurately. In this plant water was supplied to a 300-hp. water tube boiler by a direct acting pump, and as the load was not steady it was decided to run the test for 10 hr. to get accurate results. The pump was run at constant speed of about 35 strokes per minute, instead of intermittently stopping and starting

as on the previous test, since irregularity would have introduced an error in the calculation.

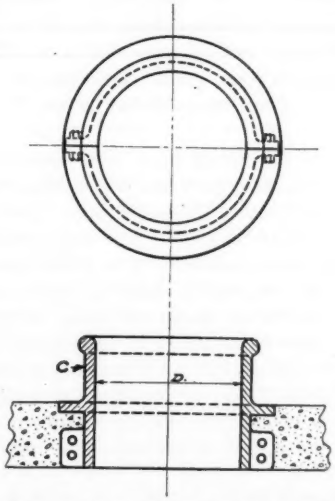
When necessary to stop the pump on account of high water level the time of stopping and starting was carefully noted. The throttle valve was marked to facilitate the speed adjustment and the steam pressure was not allowed to vary over three pounds to insure constant pump speed for a given opening of valve. When starting, the valve was opened at once to the required position and the pump instantly brought up to the required speed. Occasionally the pump was timed with a watch to obtain a check on the speed, but there was no appreciable variation.

After determining the slippage the can was no longer needed and a wooden plug was driven into the suction pipe where it entered the can. Theoretically the pump should have emptied the can in 36 strokes, but the actual number of strokes required was 46. At the end of the day the log sheet showed the total time of pump operation to be 482 minutes. This time was multiplied by 35, the result divided by 46 and the resulting figure then multiplied by 210 lb., the weight of 1 can of water. This gave 77,015 lb. of water evaporated in 10 hr., or an average evaporation of 7,701.5 lb. per hr.

Brightwood, Mass. A. F. SHEEHAN.

Handy Floor Sleeve for Piping

A PROMINENT engineering concern in the east uses a sleeve made similar to that shown in the accompanying sketch for pipes passing through all kinds of floors.



UPPER—TOP VIEW OF FLOOR SLEEVE
LOWER—SIDE ELEVATION OF FLOOR SLEEVE SHOWING CURB ABOVE FLOOR LINE

The curb *C* extends above the floor line and is intended to protect the pipes as well as to form a neat appearance around the pipe opening. It is also to prevent the sweepers from pushing dirt from the floor above down through the hole and possibly upon workers beneath or onto machinery or other equipment.

This floor sleeve is made of cast iron and in all sizes. It is also made with split lugs for bolts on the sides for the larger sizes or for placing around pipes which are already in position. In order to insure concentric alinement of the sleeves with pipes, it is advisable to leave holes in the floors larger than the actual requirements and to put the pipes in place and then locate the sleeves and grout them into position with cement.

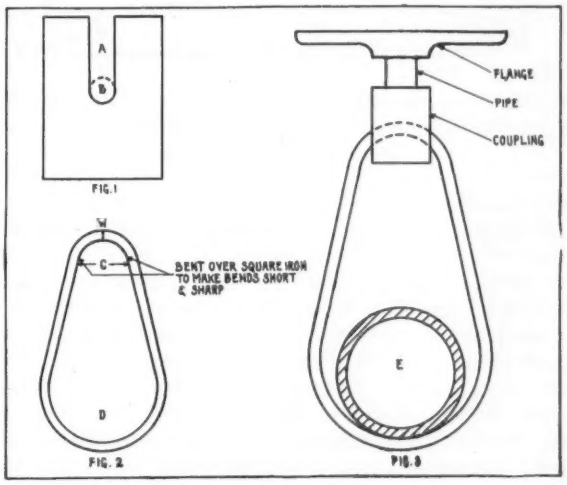
The inside diameter of the pipe sleeves should be large enough to allow passing the flange or coupling of the pipe through them. For larger sizes, for instance, *D* may be made 2 in. larger in diameter than the diameter of the pipe flange. This allows for easy working and avoids trouble if at any time changes in piping are necessary.

Newark, N. J. W. F. SCHAPHORST.

Home-Made Flexible Pipe Hangers

ORDINARY one piece iron pipe couplings, known as buckles to pipe fitters, are often sold as scrap metal in shops where much pipe is cut up for outside work. But waste material often finds practical use. As shown in Fig. 1, take such couplings, and drill a 3/8-in. hole through the sides as at B, then with a hack-saw cut down the sides thus forming the slots A.

Next make rings from an iron rod which is of the same or slightly smaller diameter than the width of the



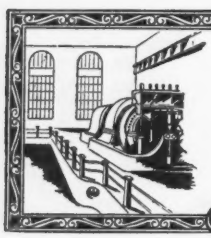
PIPE HANGER MADE OF FOUR PARTS

slots. After bending the rod, the ends are brought together and welded at W. In Fig. 2, the end of the ring is a little wider at C than the outside diameter of the coupling, and the width at D is a little greater than the outside diameter of the pipe to be supported. A small ceiling flange and an iron pipe nipple of any desired length may be used to complete the hanger.

The small end of the ring is put into the coupling slot and the hanger assembled as shown in Fig. 3, where E is the supported pipe. By having a long thread on the hanger coupling pipe any slight sag in the line may be adjusted by disconnecting the flange from the ceiling and turning the coupling further onto the thread. This home-made hanger makes a neat appearance, is inexpensive, and about as safe as any hanger can be made for moderate lengths of pipe. By making wider slots in the buckles a heavier rod may be used if desired.

For long runs of heavy pipe it is best to use roller supports when the hanger is so short that its arc of swing is not enough to take care of the expansion of the line.

Toronto, Canada. JOHN THORN.



QUESTIONS AND ANSWERS

What Do the Cards Show?

REPLYING to R.H.M., page 713, July 1 issue of Power Plant Engineering, I regret that he did not send an indicator diagram from the low-pressure cylinder, taken at the same time, as any change which must be made on the

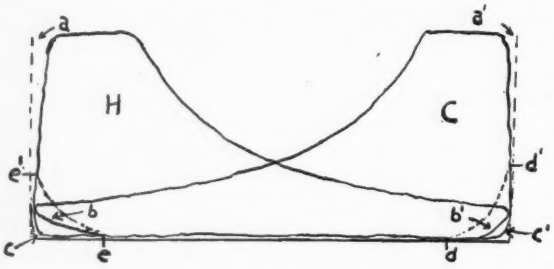


FIG. 1. INDICATOR CARD FROM 25 BY 48-IN. HIGH PRESSURE CYLINDER OF A CROSS COMPOUND ENGINE AT 63 R.P.M. RECEIVER PRESSURE 3 LB.

valve setting of the high-pressure cylinder will cause an automatic change in the low-pressure cylinder and receiver also.

In Fig. 1, admission is late. It should begin at letters e′ and d′ and follow the dotted line up to a and a′. The steam line and the point of cutoff are fair, while the expansion line and the terminal pressure are high. The curves at b and b′ indicate late opening of the exhaust ports and slow release of the steam from the cylinder to the receiver. The exhaust or back-pressure line is fair for 3 lb. receiver pressure, but the exhaust valves close too late for compression of an engine running at 63 r.p.m. This is shown at c and c′. The exhaust valves should close about the points e and d and follow the curved dotted lines up to e′ and d′, where the steam valves should open for admission of steam. In general, all events are late, due to the eccentric being set back too far.

With such a small amount of compression, there must be some pounding on the crosshead pin and crankpin boxes, even if keyed up well, and more compression would eliminate some of the pounding. Should this engine be of the riding cutoff type, the exhaust eccentric should be advanced enough to make release earlier and in doing so, it would close earlier, thus giving more compression.

The low-pressure side of the engine must not be overlooked in making such changes and the size of the cylinder must also be considered. It is not mentioned whether the engine was running condensing or exhausting to atmosphere and a compound engine using 150 lb. gage pressure, if not exhausting into a condenser, must have a fairly large low-pressure cylinder in order to allow the high pressure steam to expand to about 17 or 18 lb. absolute pressure before exhausting to atmosphere.

On the other hand, if the engine was run with a condenser, the low-pressure exhaust valves would need to close much earlier in the piston stroke than on the high-pressure side, so that the returning piston could destroy the vacuum in the cylinder and build up sufficient pressure for compression. With the high-pressure side set to cutoff at about 25 per cent of its stroke, the cutoff on the low-pressure side should be set to maintain the proper receiver pressure, which will allow the low-pressure side to exhaust at not over 18 lb. absolute pressure, if the engine is to operate economically. If the engine is run condensing, the receiver pressure must not drop below zero on light loads and may run up quite high if the cutoff on the low-pressure side is properly adjusted, or it may remain quite steady if the cutoff on both cylinders are controlled by one governor.

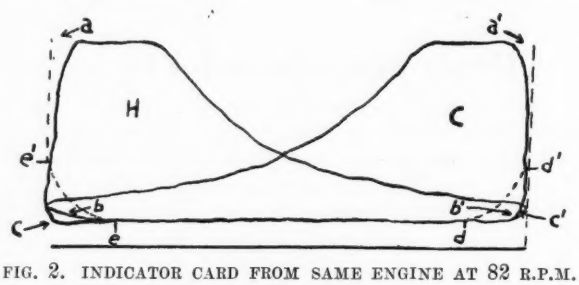


FIG. 2. INDICATOR CARD FROM SAME ENGINE AT 82 R.P.M. RECEIVER PRESSURE 18 LB.

For this reason, it would have been more interesting to readers if an indicator card had been taken from both cylinders of the engine at the same time. Low pressure exhaust valves should be set for less compression when the engine is run non-condensing than when run condensing. The amount of compression depends largely on the speed.

Figure 2 shows so nearly the same results as Fig. 1 that there is little to be said of it. The principal difference is the cutoff is slightly later, but that is partially accounted for by the 18 lb. "receiver pressure" or back-pressure on the high-pressure cylinder, which requires more power on one side of the piston to overcome the resistance on the other side.

Cambridge, Mass. R. A. CULTRA.

Which Is Cheaper?

HOW DOES the cost of operation of an electric boiler compare with one which is coal fired? I use 167 lb. coal per hr. at a cost of $7.65 per T. It has a heat value of 13,500 B.t.u. per lb. and the efficiency of the boiler and furnace is 60 per cent. When using electricity, the cost would be 2c per kw-hr. and the efficiency of the electric boiler assumed to be 96 per cent. L. B.

A. The figures which you submitted on the operation of a coal fired boiler show that you were using coal at a cost of 64c per hr. With a coal having a heat value of 13,500 B.t.u. and operating at 60 per cent efficiency, you were producing 40.3 b.hp. per hr.; (13,500 × 0.60 × 167)

÷ 33,500 = 40.3 b.hp-hr. You were then producing 1390 lb. of steam per hr., which gives the figure of 46c per 1000 lb.

Now, if you were to generate 1000 lb. of steam electrically, 1000 × 970.4 B.t.u. would be 970,400 B.t.u. needed. Then, if you assume the efficiency of an electric boiler as 96 per cent, 1,010,830 B.t.u. would have to be produced to give the 1000 lb. of steam. Since the heat equivalent of 1 kw-hr. is 3411 B.t.u., then 1,010,830 ÷ 3411 = 296 kw-hr., which would be the amount of power required to produce 1000 lb. of steam. At 2c per kw-hr., it would cost $5.92 to produce the same amount of steam as could be generated with coal firing for 46c.

It is obvious, therefore, that steam production by means of electricity is not feasible unless electric power can be obtained very cheaply. An electric boiler is efficient but not economical.

How to Determine Furnace Volume

IN A RECENT examination, one of the questions was how to determine the furnace volume necessary for a return tubular boiler. Is there any formula or rule for this?

W. J. W.

A. There is no definite "formula" for determining the dimensions necessary for the furnace of a return tubular boiler, or any other kind of boiler. That is, we mean an exact mathematical formula which will comply with all conditions. The examiner who gave this question did not intend it to be answered with a direct statement, but, no doubt, expected the man taking the examination to elaborate on the conditions to be expected, possibly supply certain specific conditions, and then proceed with the dimensions of this assumed size of boiler setting and other things necessary for successful operation.

The first thing to know is the size of the boiler and its so-called rating in boiler horsepower, which is, of course, dependent upon the number of square feet of heating surface. With this known, the next thing is the size of the grate. This must be in proportion to the number of square feet of heating surface and the maximum load to be carried. If we assume a 150-hp. return tubular boiler, this boiler will then have 1500 sq. ft. of heating surface. If a boiler is to be run at extremely high rating, the ratio of heating surface to grate surface should not be over 35 to 1, and even if run at not much above rating, the ratio should not be much more than 45 to 1. Therefore, for average all around conditions, it is always a good plan to install a grate with which the ratio of heating surface to grate surface is 40 to 1. Then, with 1500 sq. ft. of heating surface, there would be 37½ sq. ft. of grate surface.

Length and width of the furnace are already determined by the size of the boiler. Thus, if you have a boiler 72 in. in diameter by 20 ft. long, the setting will be approximately that length and the width of the grate will be approximately 6 ft. Of course, it is possible, and may even be necessary, to have a longer setting by means of a dutch oven, if certain particular kinds of fuel are to be used, but assuming that we are to burn average bituminous coal, we will not have a dutch oven, but the setting will be known as "flush front."

With all boiler settings where coal is burned on some sort of grate, there must be a bridge wall. In return tubular boiler practice, it is ordinarily good policy to build this bridge wall so that the area of the opening between the shell of the boiler and the top of the bridge wall will be 20 to 25 per cent of the grate area. Probably 25 per cent is the better, so that, if we have 37.5 sq. ft. of grate, then the area of this opening should be approximately 10 sq. ft. This would then require the distance from the shell of the boiler to the top of the bridge wall to be about 20 in.

We have not yet stated how high the boiler should be placed above the floor line. This is really the most important item, since it will determine the volume of combustion space, for the other two dimensions, as previously stated, are predetermined. In the past, a rule-of-thumb method for determining the size of the combustion space has been to allow 2 cu. ft. of furnace volume per horsepower developed. As may readily be seen, this is not accurate, since it does not take into consideration the quality of fuel to be burned. More modern practice adopted a design of furnaces on the basis of allowing 1 cu. ft. of furnace volume for each 18,000 to 24,000 B.t.u. liberated per hour. We will now assume that you are to operate this 150-hp. boiler at 200 per cent of rating. This will then give 300 hp. developed per hour.

Assume now that you will use 5 lb. of coal per horsepower-hour. This will give 1500 lb. of coal per hour. Supposing, then, that the coal has 10,000 B.t.u. per lb. We then have 15,000,000 B.t.u. liberated per hour. If we allow 1 cu. ft. of furnace volume for each 20,000 B.t.u., we must then have 750 cu. ft. of furnace volume. Since the width of the furnace is 6 ft. and the length 20 ft., the height must be approximately 6½ ft. Since the gases do not appreciably drop down below the level of the grate as they pass the bridge wall, it is usually good practice to consider the effective height of the furnace to be on the level with the grate and, therefore, the boiler should be placed between 6 and 6½ ft. above the level of the grate. The setting drawing, however, usually specifies the height of the boiler above the floor line, so that, if the top of the grate is 2 ft. above the floor line, the height of the boiler above the floor line will be 8 to 8½ ft.

This should give you a fairly good idea how to figure the dimensions of a boiler setting. This does not apply to a return tubular boiler in particular, but may be used with any kind of boiler used in power plants.

This size of furnace is much more liberal than is ordinarily found with the older installations of return tubular boilers, since, as originally installed, they did not intend to operate at much above rating, and if they did, they smoked badly. With this size of setting, a return tubular boiler in good condition should approximate the efficiency obtained with a modern water tube boiler.

THERMODYNAMIC THEORY defines efficient heat cycles. It is possible to make great improvements in the efficiency of a steam plant by the application of this theory. It results in what is known as "heat balancing," that is, so choosing, proportioning and arranging auxiliary equipment that the plant processes will conform closely to the requirements of an efficient heat cycle.

THE EDISON Electric Illuminating Co., Boston, Mass., is said to have contracted for earthquake insurance on its power properties in an amount of $45,000,000. This type of insurance, it is stated, is growing rapidly among light and power companies seeking protection from such disasters, due to recent occurrences.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

We Have Been Waiting for This Development

Lloyd George said, in a recent address: "On the proper use of coal and the proper development of power depends largely the future welfare of our race. The present generation has no more important and more helpful task than to let sunshine into our towns, and to house all classes of citizens in places where the light and air of Heaven is pure and undefiled. I believe profoundly that such a step would sweep away the dangers and disgraces of our existing slums. No effort to accomplish this end can be too great."

The average person consumes a little less than 6 lb. of food and water every 24 hr. During the same period, however, he takes in nearly seven times that weight in air. The lungs are far more delicate in structure and in function than our digestive organs—yet in Chicago alone, 90,000 T. of soot falls every year. That was the estimate arrived at by a dis-interested and unbiased research firm. The presence of smoke and other foreign matter in the air is withholding from every city an astonishing percentage of sunlight. The percentages range, depending upon the city, from 12 to 84.

Yet even when unadulterated sunlight does reach us, the lead in our window glass prevents the entrance of the actinic and ultra-violet rays. This is costing us health to a great degree. It retards the good results of our 7500 hospitals. Quartz glass permits the entrance of the desirable rays, but its cost is prohibitive.

Now comes the announcement that two Austrian scientists have developed a new kind of glass—one of organic origin that permits the passage of the ultra-violet rays. The new glass is called Pollopas, and is made by a chemical condensation of urea with formaldehyde. It is only about one-half as heavy as our common glass and is exceptionally transparent.

Development of this new material will shake the glass industry from stem to stern, and result to the distinct benefit of the human race.

Commercial Aviation Soon to Be Basic Industry

Since the beginning, the exercise of foresight has been the determining factor in the success or failure of every enterprise. The reason for the outstanding success of certain corporations, or the astonishing accumulation of wealth by certain individuals, can invariably be traced to either one man or a small group of men who are possessed with vision. The Astors and the Vanderbilts bought cheap land on Manhattan Island. Marshall Field believed in Chicago—and mortgaged his property to buy more property. Much of our fruitful Northwest owes its excellent start to the vision of James J. Hill. The International Harvester Company spends nearly one million dollars annually in the education of the farmer's children. The American Telephone Company has laid conduits from coast to coast sufficiently large to take care of the growth in telephone service for the next 40 yr.

On the other hand: phonograph companies were nearly swept out of business because they pooh-poohed the development of the radio. Not 10 furniture manufacturers were prepared to meet the competition of metal furniture. The millwork folks and lumber people are only now realizing the damaging influence of substitutes. The St. Luke's hospital in Chicago is 19 stories high and there isn't a stick of wood in it, either in construction or equipment.

There has never been a time when the exercise of vision was more imperative. Patents are being issued in this country at the rate of 1000 a week. Far-reaching developments and revolutionary improvements are being made in every field of endeavor. The development of synthetic, fire-proof shingles has put a serious dent in the business of cedar shingles. The production of silk from spruce wood and cotton waste has materially reduced the importation of silks from the Orient. Sugar from corn is seriously disturbing the cane and beet refiners. The automobile and the electric transit have taken people off their feet, with the result that the shoe industry is hard pressed. Down in Texas a man has developed a centrifugal separator which whirls the meat from crab shells automatically—and which does the work of over 200 men.

During the next few years we shall witness the rapid development of aviation in this country. Since July 1, Chicago and New York residents can send mail back and forth overnight. The recent organization of the National Air Transport, Inc., with a capital of $10,000,000, for the carrying of fast freight and express matter between New York and Chicago is a signal step in the development of civil aviation. Aeronautical experts foresee the early development of at least ten other routes, radiating from New York, St. Louis, Chicago, Salt Lake City and San Diego. Daniel Guggenheim recently announced the endowment of $500,000 for the founding of a school of Aeronautics in the College of Engineering of New York University. This school, the first of its kind, will not only train engineers in the design of craft and the management of aeronautical enterprises, but will force other universities to include aeronautics with their curricula.

If there is an idea lurking in the mind of anyone that we have seen far-reaching changes, or passed through a period of commercial stress, during the past ten years, that person will have to devise new adjectives and stronger words to define the character of the era now approaching.

Railways Pressing Motor Trucks Into Service

During the past 21 months the electric railways of this country increased their motor bus equipment 230 per cent. The railway-owned motor bus mileage increased, during this same period, 275 per cent. The number of railways, both steam and electric using busses increased 70 per cent.

The American Railway Association officially recognizes the motor bus as an important factor in meeting the transportation needs of the public. Particularly in the matter of short haul, and less than car load lot freight, have motor trucks been used to the advantage of both shipper and carrier.

Mr. Quinlan, Superintendent of Cook County's Highways states that on the average day, the total motor traffic entering and leaving the City of Chicago exceeds 110,000 vehicles. This, it seems, is about 36 per cent of the total motor registration in Chicago. Of these vehicles, nearly 6000 are trucks, which carry from or to the city over 6500 T. of commodities. The one hundred thousand odd passenger cars average 1.9 persons per car, and since the average daily motor mileage in Cook County is approximately 990,000 mi. we find the motor car depriving other transportation mediums of at least 1,800,000 passenger miles every day.

Synthetic Lumber on the Way

In the conversion of a tree into merchantable lumber, it is estimated that about 60 per cent is wasted. After considerable experimentation, the New York State College of Forestry now announces the discovery of a process for the utilization of this waste. The process is one that reduces all slabs, bark, twigs, sawdust, pieces of board and roots, to a cellulose compound which can be made into boards of any shape or size. In addition to the value which arises from the conservation, the product has thus far proven to be immune to decay. A non-rot wood.

A new nickel-chrome alloy has been produced which possesses great resistance to corrosive acids; will withstand a permanent heat of 1800 deg. F. without scaling, cracking or warping, and which has a tensile strength under this high temperature of about 30,000 lb. It has the hardness of cast iron, and since nickel-chrome alloys have steadily become increasingly important in many branches of engineering, this new metal should prove a far-reaching development. Its advantages should off-set the difference in price. As an example of its endurance, it can be said that annealing boxes made of this new alloy will last 5000 hr., whereas the life of an ordinary steel box is seldom in excess of 200 hr.

A Nation of Stock and Bond Holders

Due in large measure to the financial education given the general public by the Liberty Bond Campaigns, there has been an astonishing increase in the number of citizens who have placed themselves in the bond and stock holder class since 1913. Prior to the war, the number of stock holders in the nation's industries was approximately 4,500,000. Today the figure is said by H. T. Warshow, nationally known economist, to be in excess of 14,400,000.

In 1917, only 9.7 per cent of the total number of persons, whose incomes were less than $5000, annually received dividends from stocks or bonds. This proportion has now increased to over 20 per cent, the peak being reached in 1921 when 22.7 per cent of the total of all persons filing this class of income tax statement showed stock or bond dividends to be a part of their income.

In 1915 the total number of stockholders in Class I railroads was 511,000, and the average holding, per stock holder was $13,361. At the present time, according to the reports filed with the Interstate Commerce Commission, this number has increased to 807,000 and the average holding has decreased to $9110. While this increase is not so pronounced as in the case of industrial holdings, it is perhaps more remarkable because of the dearth of new railroad stocks during the 10 yr. from 1914 to 1924.

Paralleling the increased distribution of ownership of securities is the growth of savings bank deposits and of life insurance policies. In 1913 the total insurance in force was slightly in excess of fifteen and one-half billion dollars, while at the beginning of 1924 that figure had been increased to nearly 57 billion dollars. A report from the American Bankers Association shows an increase in savings deposits from $8,400,000,000 in 1912 to $20,874,000,000 in 1924. During this same period, the number of depositors increased from 12,584,000 to 38,868,000.

In commenting on the astonishing increase in savings account depositors, William E. Knox, President of the American Banker's Association, said: "The full significance of this is realized only when we visualize savings deposits as meaning much more than merely dollars in the banks. They really mean an increase in the accumulated productive capital of the country, since money deposited in the banks as savings is promptly applied by the bankers to the purchase of securities by which plant, railroad and other industrial developments are made possible. These figures mean, therefore, that the small savings of many millions of people, instead of being frittered away in the purchase of goods that are immediately consumed, which involves a destruction of capital, are gathered together and applied in the better utilization of capital through the upbuilding of industrial equipment. This means the preservation and perpetuation of the country's physical wealth and its application to the production of further wealth more easily and in larger volume, resulting in a high standard of living for all classes in the country."

Safety Inspections—Where and When

Carl B. Auel, president of the National Safety Council, has set forth his ten conditions for safety. They are well worth serious thought by every executive and worker, since "any plant can be made as safe as the management and the workers want it to be." The Commandments are as follows:

Health and contentment. Minimum labor turnover. Cleanliness and neatness. Good lighting. Prohibition. Education. Intelligence, skill and care. Mechanical and equivalent guards. Knowledge of English language. A measured pace.

Mr. Auel has also set forth a brief list of mechanical equipment that requires periodic inspections. He believes the following table covers the average plant and sets forth the maximum periods of time for safety inspection.

	Interval Between Inspections
Stair treads and railings	3 mo.
Warning signs	12 mo.
Elevators	Constantly
Cranes, crane chains and hooks	Constantly
Emery wheels, guards and water supply	6 mo.
Gas masks	12 mo.
Goggles and sterilizing outfits	6 mo.
Hand tools, mushroom heads, broken handles, etc.	6 mo.
Crane operators (physical examination)	12 mo.
Food handlers (physical examination)	6 mo.
First-aid cabinets	Weekly
Stretcher cabinets	12 mo.
Window cleaner's belts and window eyes	6 mo.
Ladders	6 mo.
Hand trucks	6 mo.
Safety meetings	1 to 3 mo.

EDITORIAL COMMENT

An Efficiency Ratio for Operators

Too often, in the operation of a power plant, all the factors affecting efficiency are not given proper consideration and the operating force is judged by power produced per pound of coal used, regardless of influences outside their control. Nobody questions the fact that choice of equipment, plant design and construction have much to do with the results to be obtained in generating power. Likewise, the character of the load placed upon the plant is reflected in the economy of the plant. Other factors, such as condensing water temperature and weather conditions, often prevent the operating force from securing the highest possible results.

In some plants, where the bonus system is used, standards have been established to govern payment of the operators. This undoubtedly was a step in the right direction and has led to the use of a system of comparing actual results with those theoretically possible, as used in the Lakeside Station of the Milwaukee Electric Railway and Light Co.

It will be noted in the article by Mr. Drewry in this issue that the term "operating efficiency ratio" is used to express the relation between actual and theoretically possible results. This efficiency averages about 95 per cent in the Lakeside Station and we have no doubt the psychological effect of securing so near to 100 per cent is a wonderful stimulus to the operating force. The man or the department of a power plant, which does all that can rightfully be required of it, should be rated at 100 per cent. It is decidedly unjust to hold the operating force responsible for low efficiency due to causes outside their control and every man in the plant will welcome a system which will give credit where credit is due.

Standard Practices Will Aid Structural Steel Design

Most engineers are by this time sufficiently familiar with the history of the steel industry in this country to understand how vitally the whole course of modern industry has been affected by progress in steel making. This progress has been especially marked during the first 25 yr. of this century by increasing knowledge of how to make and use steel for the frame-work of buildings. Yet in spite of all the efforts of the various manufacturers of structural steel, there has existed until comparatively recently a most confusing lack of uniformity not only in regard to the proper unit stress to use, but also in regard to the application of it. Then, too, the multiplicity of column formulas prescribed by various cities has led to much unnecessary labor, to waste of material, and in some cases has tended toward unreliability of structures.

In a paper recently delivered before the American Iron and Steel Institute, these points were forcibly brought out. The speaker pointed out that although the various steel manufacturers have exerted much influence, through their mill handbooks, their standardization of shapes, and their specification of 16,000 lb. per sq. in. as a unit stress to cover all cases, there still remained much to be done. It has remained for the Institute to unify and continue this work, for which it should be commended.

In view of the developments in steel making in recent years, the old unit stress of 16,000 lb., including as it did a generous "factor of ignorance," has been found too conservative. In the Standard Specification, recently issued by the Institute, the basic unit stress has been raised to 18,000 lb., which is still a conservative figure, but has often been used in recent years in bridge work. A Standard Manual, in which all the data needed by the designer regarding each size of a given product will be grouped on one page, is now in preparation. A Code of Standard Practice has been published, which, among other things, defines a plumb building, something that has never been done before.

These and other activities that are being carried on at present by the Institute are of interest to all engineers. This organization is to be congratulated on the work it has already accomplished and on the plans it is making for the future. Its work aims to foster good structural design, good workmanship and, above all, safety and reliability, which are the governing factors in this great work of building in which the engineer plays such a prominent part.

Many Factors Determine Economy of Hydro-Steam Parallel Operation

As a result of improved methods of transmitting electric power and the development of remote control and automatic switching devices, it is now feasible to utilize in interconnected power systems many water powers that otherwise could not be developed economically, operating the hydro plant or plants in parallel with a steam plant.

When this is done, a number of apparently subordinate features will determine the economy of the combination, as F. A. Allner points out in this issue. During periods of high and low flow, the load must be properly divided to obtain maximum service from the hydro plant. The high service demand availability factor of the latter often permits a large saving of investment for spare steam capacity. Carrying on of repair work at different seasons in steam and hydro plant by the same working force makes for convenience. Use of the hydro plant generators as synchronous condensers for the system during the off-peak time and of a frequency indication signaling system as discussed by Mr. Allner, are of particular interest.

This question of parallel operation is daily becoming of more importance to every power plant engineer, since its possibilities exist in the industrial as well as in the central station field. If attention is given to the points brought out by Mr. Allner, good operating conditions and high economy should ensue when the "white coal" and the "black diamonds" are sharing the load.

Shall We Buy Coal on a B.t.u. Basis?

For a long time the purchase of coal on a B.t.u. basis was considered the best way to insure an acceptable quality of fuel. Many plants still follow this method without consideration of the characteristics of the particular kind of coal they are buying. It is true that if we assume the time worn premise—"Other things being equal"—that coal of 14,000 B.t.u. per lb. is better than coal with only 10,000 B.t.u. per lb.

But other things aren't always equal. In the pre-stoker days, when hand-firing was the accepted method, almost any kind of fuel could be thrown on the grate and if allowed to remain long enough with much excess air, could be burned more or less efficiently. Under those conditions, the power plant owner thought that the more heat units he got for his money the more he was saving.

While not exactly right, his reasoning was much nearer correct than it is today. Stoker firing is probably the biggest factor in combustion practice. The pressure of modern business demands efficient methods. Where once we were satisfied with 100 per cent of boiler rating, we now must have 300 per cent or greater. Stokers are called upon to meet peak loads within periods unheard of in former days. Combustion rates are mounting higher and higher. But we must not lose sight of the fact that Time is the controlling factor.

Power plant owners are beginning to realize that since time is such an important item they must have coal which will do the most in saving time. This means the coal must be adapted to the stoker and furnace. Modern combustion practice is to build a stoker and furnace to suit certain types of coals.

If a furnace is designed for fuel with a high volatile content, fuel with this characteristic must be obtained if good results are to be expected. This is particularly true in the case of chain grate stokers, where, in case of extreme variation between light and heavy loads, the fuel must move at a comparatively rapid rate in order to meet the demand. Here coal with high volatile matter will give the best results, but if, as is often the case, a well meaning but misinformed purchasing agent supplies coal with a low volatile content because it happens to have a higher heat value than the coal he has been buying, trouble and dissatisfaction will result.

In plants where a quick pick-up in load must be made at a moment's notice, coal with 10,000 B.t.u. per lb., if the volatile matter is high, will generally give better satisfaction than fuel having 13,000 to 14,000 B.t.u. per lb., but a small amount of volatile matter.

On the other hand, we have known of cases where furnaces have been designed for fuel with a minimum amount of volatile matter and then, because certain other fuel, with price figured on a B.t.u. basis, could apparently be purchased more cheaply than the original fuel, it was decided to use this latter fuel.

Trouble began immediately. When attempting a quick pick-up the furnace smoked excessively, ash analysis showed 35 to 40 per cent carbon and in a short time the ignition arch showed signs of severe erosion.

Instead of allowing the heat value of the coal to be a primary consideration, we would suggest that an accurate proximate analysis, together with a determination of the fusion point of the ash, be considered the standard of coal purchase. Coal having ash with a fusion point above 2500 deg. F. is most desirable, at 2300 deg. F. it is fair, and below 2100 deg. should not be acceptable.

Do You Make Progress?

Some methods, which are of long standing, often become so much like a habit that they are hard to discard or to supplement with those which would be more satisfactory and productive. The age old characteristic of "let well enough alone," or "this is the way it has been done for many years" is entirely too predominant. It is not meant that all old practices are inadequate or cumbersome but it does mean that executives or those in charge of responsible work should be open-minded and not only willing to adopt improved methods but, in fact, they should be searching constantly for new methods.

All of this applies not only to the practice of routine details but also to the practices involving the more important problems of operation and of management. In many cases, there will be found a willingness to show signs of progress when it comes to minor changes, but as the importance of the change increases there is a greater tendency to stall along with such hesitancy that much valuable time and effort is lost.

As an example of this, witness the Executive Order, dated June 4, in which the President transferred the Bureau of Mines from the jurisdiction of the Secretary of the Interior to the Secretary of Commerce. This is a change which could profitably have been made a number of years ago and had it been done then the Bureau would long ago have been co-ordinated in its work under the new Department and the benefits now expected would have been in practice for some time rather than anticipated for the future.

We are all inclined to criticize government, both state and national, because of its lack of aggressiveness; however, wouldn't it be a good idea first to study our own methods? It probably is an even bet that our own aggressiveness is more of a mental condition than an actuality.

Little Things Count

In an old fable, a tiny ant once saved the life of a huge elephant. For the industrialist, that fable means "Pay attention to the little things."

One official in a medium sized plant found, after a little research, that the operation of winding time clocks, recorders, etc., cost him $210 a year. Few would ever think of clock winding as an expensive operation.

A machine costing $25,000 to build and install in one of our public utilities, failed to operate properly when started. The cause of the trouble was traced to an inaccurate micrometer, costing $5.50.

In Milwaukee, a sausage-making plant recently suffered a serious loss in production. After a great deal of time-consuming and expensive research the cause was found to be a $28 belt.

Production of a machine shop located in Cincinnati increased 22 per cent when the original 100-watt lamps were replaced with 200-w. globes. In Toledo, the spoilage of one factory decreased over 50 per cent after the windows and lamp shades had been washed—an operation costing about $30.

Big wastes are more or less obvious and easy of correction. It is the little operations, the details, that harbor the real danger to the welfare of the dividends. Watch the details. Know what you are buying and what you are selling. Know from whom you buy and to whom you sell. In terms of production and distribution, knowledge is profits.

Initial Units at Peoria Rated at 40,000 Kw.

New Pulverized Fuel Burning Station of the Illinois Electric Power Co. Will Have an Ultimate Capacity of 100,000 kw. By H. G. Kniese

PRESENT CAPACITY OF the new East Peoria steam-electric generating station of the Illinois Electric Power Co. is 40,000 kw. and provision has been made for an ultimate capacity of 100,000 kw. This plant is located on the east bank of the Illinois River just opposite the main business section of the city of Peoria, Ill. This location meets the fundamental requirements of a good central station site in respect to circulating water, fuel supply, nearness to load center and the price of land.

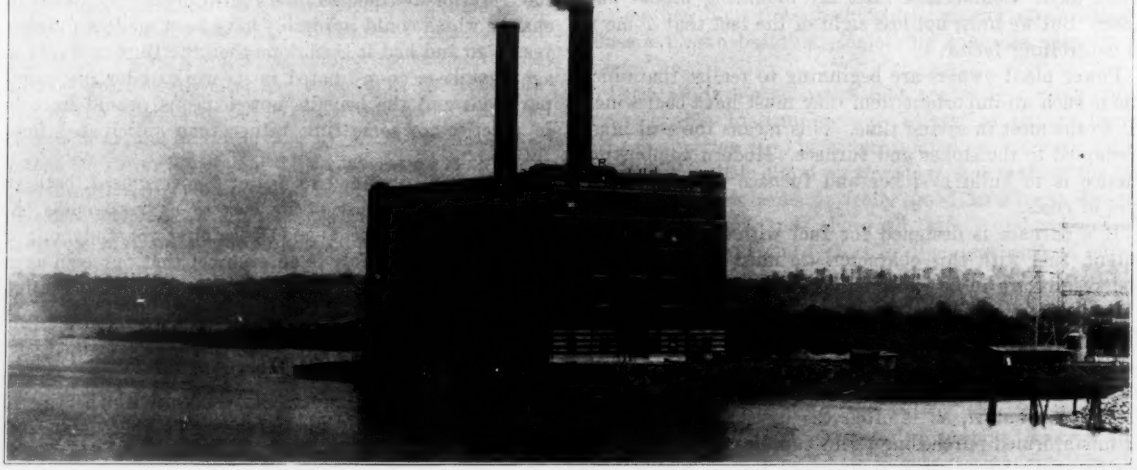


FIG. 1. ARCHITECTURAL APPEARANCE OF THE BUILDING WAS STUDIED WITH CARE BECAUSE OF ITS PROMINENT LOCATION

Owing to the prominent location of the plant considerable attention was given to the architectural appearance of the building. The design of the building is artistic and the appearance more attractive than that of the usual power station. The present building is 117 ft. 5 in. wide by 216 ft. long. The ultimate size of the building will be 117 ft. 5 in. wide by 489 ft. long. The height of the building is 102 ft. 7 in. above grade. The building is supported on a reinforced concrete substructure resting on concrete piers which extend down approximately 50 ft. to blue clay shale. The basement of the turbine room is of a sufficient depth so that there will be a head of water on the circulating water pumps at all times.

At present the installation includes two Allis-Chalmers main units rated at 25,000 kv.a. at 80 per cent power factor, each being capable of carrying 23,500 kw. with maximum stage bleeding. The house generator is carried on the shaft of the main unit and on the end of the house generator shaft there is a direct connected exciter serving the house generator only. The main generator is separately excited at 250 v. by motor generator sets. All of the turbine auxiliaries are motor driven, the current being supplied from the house generators.

Each turbine has a 25,000-sq. ft. Alberger surface condenser of the two-pass type. The circulating water for the condenser is supplied by two constant speed motor driven circulating pumps, each having a capacity of 30,000 g. p. m. During light loads or when the temperature of the circulating water is low, one pump will be sufficient to meet the requirements. All of the motor driven auxiliaries can be started by remote controls which are located on the panel board alongside of the main units on the turbine room floor. Each condenser has its own circulating water intake. The water is screened through a revolving screen and after circulating through the condensers, is discharged into a common tunnel which runs the entire length of the building.

Steam is bled from each of the two turbines for the Griscom-Russell evaporators and heaters which are used for heating the boiler feed water. This system is designed for supplying 3½ per cent make-up. A concrete clear well

and storage tank is provided in the basement of the building to take care of the surges in the boiler feed make-up water.

Four 1392-hp. Springfield boilers of the cross drum water tube type, with a drop bank of tubes to provide space for "Elesco" inter-deck superheaters are now installed. Below the superheater are six rows of tubes. Additional boiler surface, 1210 sq. ft. per boiler, is provided by a water screen at the bottom and the rear of the furnace. This is connected to the boiler circulation. The boilers are designed for a maximum rating of 350 per cent at steam pressure of 400 lb. ga. with 250 deg. F. superheat. The steam pressure will be maintained at 350 lb. ga. at the turbine throttle. The boilers and furnaces are fitted with a steel jacket and are insulated with Sil-O-Cel brick.

Each boiler is fired by 10 vertical pulverized fuel burners. A furnace volume of 16,000 cu. ft. provides, at the maximum rating of a boiler, that slightly less than one pound of 10,000 B. t. u. coal will be burned per cubic foot. The flame travel is approximately 45 ft. The pulverized fuel equipment was furnished by the Combustion Engineering Corp.

Each boiler has a single-pass, counter-current, high-pressure Foster steel tube economizer, which contains 8400 sq. ft. of surface. Green induced draft fans discharge the flue gas into 13 ft. inside diameter, brick lined steel stacks, the tops of which are approximately 197 ft. above grade. There are two boilers per stack.

Green coal is handled into the plant through an outside coal hopper and drag conveyor. The coal is crushed before being elevated to the green coal hopper. From the green coal hopper the coal passes through flue gas coal dryers to the pulverizers on the basement floor. The pulverized coal is carried to the separators and fed by a screw conveyor into the pulverized fuel bins. From the pulverized fuel bunkers, the coal is fed through feeders directly to the burners. Each boiler has a large concrete ash-hopper

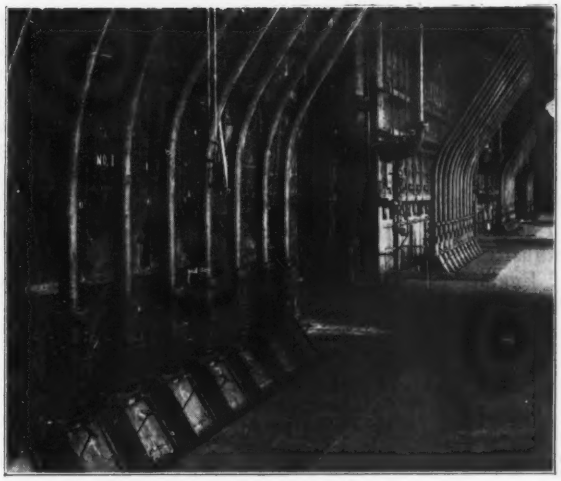


FIG. 2. TEN VERTICAL PULVERIZED FUEL BURNERS SERVE EACH FURNACE CONTAINING 16,000 CU. FT. OF COMBUSTION SPACE

equipped with a hydraulic gate. A concrete brick lined ash sluice is used in sluicing the ash to a No. 8 Morris, manganese lined, motor driven pump which discharges the ash to the points on the plant site which are to be filled. Sufficient space is available for ash storage for many years.

The electrical switchboard, switchroom and reactor structure are located on two floors directly above the turbine room. General Electric Co. switchboard, reactors and truck-type breakers are used throughout. A Warren master clock is provided and all recording instruments are motor driven. Owing to the complicated footing construction, it was advisable to place the electrical equipment above the turbine room rather than to build a separate building adjacent to the main structure.

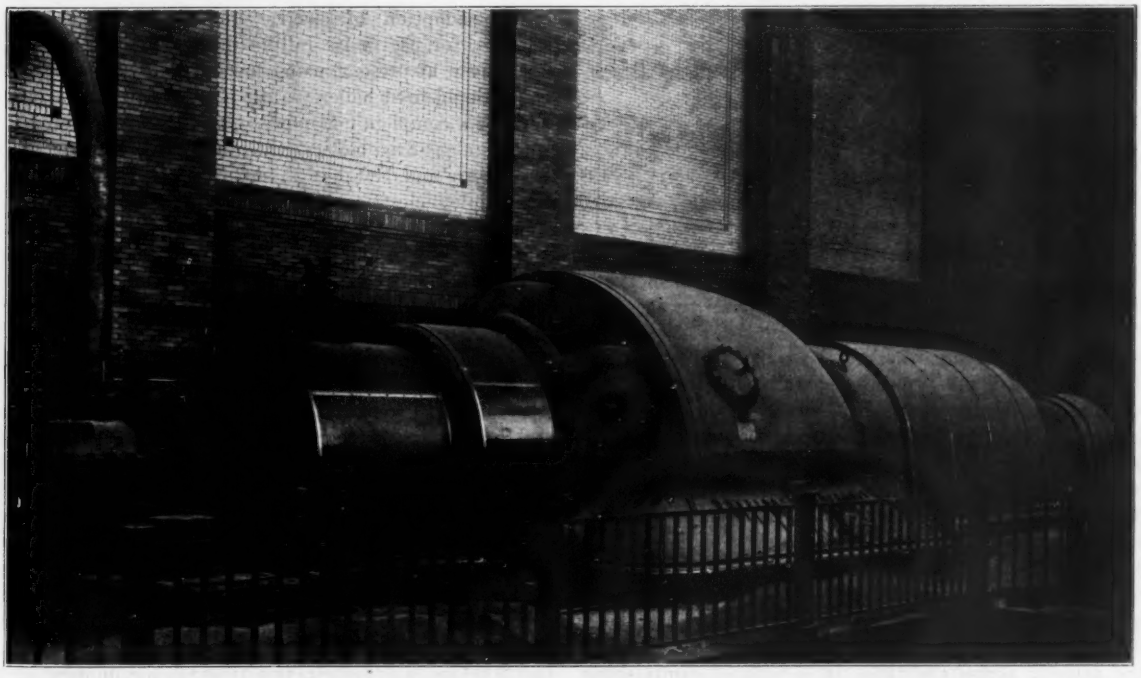


FIG. 3. HOUSE GENERATOR IS MOUNTED ON THE SHAFT OF THE MAIN UNIT. THE EXCITER ON THIS SAME SHAFT SERVES ONLY THE HOUSE UNIT

Current is generated at 13,200 v. and all cables go out underground. Four submarine cables cross the Illinois River and connect with the Central Illinois Light Co.'s Harrison St. substation. Another portion of the station output is stepped up to 132,000 v. and sent through a 30,000-kv.a. steel tower transmission line to the Illinois Power Co. at Springfield, Ill., which is approximately 70 mi. south. There are other transmission lines planned for supplying the surrounding territory for a considerable radius.

Engineering work for the station was accomplished by the utility company's organization at Peoria.

Feed-Water Heaters for Regenerative Heating

REGENERATIVE heating of feed water by means of steam extracted from successive stages of steam turbines has necessitated the careful design of closed or surface feed-water heaters. The conditions of this service are most favorable to the use of closed heaters, as the feed supply is condensate containing little or no scale-forming impurities and there is no oil or grease in the steam.

Cochrane Corp. closed heaters have been designed to facilitate inspection and cleaning of the heating surfaces if necessary and to eliminate expansion and contraction strains. Straight tubes of brass or other suitable mixture are expanded at the water box end into a fixed tube sheet and the water box is provided with division plates which compel the water to make one or more passes through the tubes, the number of passes being chosen according to the amount of water and the temperature rise.

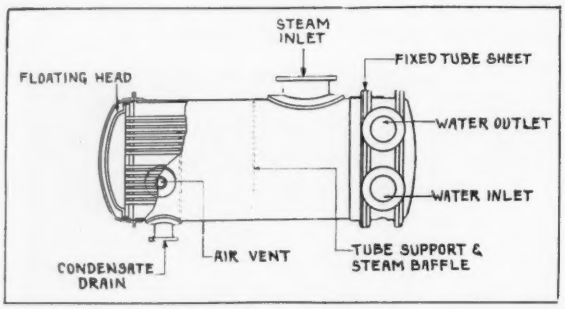


FIG. 1. TWO-PASS CLOSED HEATER WITH FLOATING HEAD. STEEL PLATE SHELL CONSTRUCTION

Floating heads are used at the opposite end of the tube bundles. There are two separate and independent heads, one for each return of the flow and the heads can slide within the shell and also upon one another. The water in the third and fourth passes is considerably hotter than the water in the first and second passes and the division of the floating head into two parts permits of independent expansion, eliminating to a large extent strains upon the tubes and their fastenings.

Steam circulation is through perforated baffles extending part way across the tube bundle, which serves both to support the tubes and to compel the steam to flow at high velocity across the tubes in a path of diminishing cross section, so that all air and other non-condensable gases are positively pushed forward to the vent opening.

Where it is desirable to be able to remove the entire tube bundle from the heater without removing the tubes from the tube sheets, the type of shell shown in Fig. 1 is used; that is, the entire length of the shell is of the full diameter corresponding to the floating head. Otherwise the type of shell shown in Fig. 2 is to be used, since better and more rapid steam circulation is insured by having the shell hug the tube bundle closely. The tube head, water box and water cover are separate castings. Through bolts are used on the outside flanges and covers. Supporting brackets are cast integral with the shell or separate cradles are supplied for steel shells. The steel plate

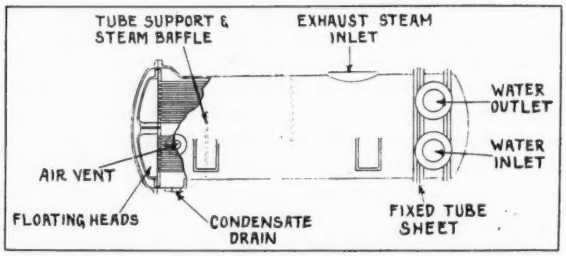


FIG. 2. CLOSED HEATER WITH DIVIDED FLOATING HEAD. CAST IRON SHELL CONSTRUCTION

type of shell shown in Fig. 1 is used where high pressures are to be carried or where this type of shell is desirable for other reasons, as for saving weight. In small heaters having short tubes, it is not necessary to use floating heads, both tube sheets being fixed.

Colorado Fuel & Iron Co. Builds New Power Plant

AT ITS Minnequa Works, Pueblo, Colo., the Colorado Fuel & Iron Co. has recently completed arrangements for the adoption of electric power, generated on the premises, for use in its rolling mills. The mills are engine driven at present, using low pressure steam obtained from a hand-fired boiler plant. This plant will be superseded by a complete new power plant, using powdered fuel and waste-gas-fired boilers, which will provide steam at 300 lb. pressure and 180 deg. F. superheat.

Complete electrical equipment will be furnished by the General Electric Co. Two 10,000-kw. turbine generators will be the prime movers and will furnish alternating current to the main power lines at 6600 v. Other power house equipment will consist of one 150-kw., turbine-driven exciter and one motor-driven exciter unit. Two 1000-kw. synchronous motor generators will furnish direct current for operating power house auxiliaries and will tie in with other direct-current mill power circuits. Two 200-kw. generators, driven either by steam turbines or by induction motors, will be used to start the station auxiliaries in the event of failure of power from other sources. Three single-phase reactors will limit the short-circuit currents on the auxiliary alternating current bus. A complete switchboard will also be installed in the power house.

Complete electrical equipment will be furnished for driving a rod mill, a 10-in. merchant mill, a 14-in. merchant mill and a rail mill. The rod mill will be driven by two 3000-hp. a.c. motors, two 1000-hp. a.c. motors, and a 1500-hp. d.c. motor. The 10-in. merchant mill will be driven by two d.c. motors, direct connected of 300 and 1500

hp. The roughing stand of the rail mill will be driven by a 2000-hp. 450 r.p.m., induction motor, a 3000-hp. induction motor and a 1200-hp., 450 r.p.m., induction motor, each motor being geared to the mill through the usual double herringbone reducing rear.

New Liquid Level Gage Uses Mercury U-Tube

TO MEASURE or indicate the level of liquids at a point remote from and below the actual level of the liquid being indicated, the McNeill Liquid Level Gage has been designed. It is particularly adapted to indicating the water level in boilers where the height of the boilers or

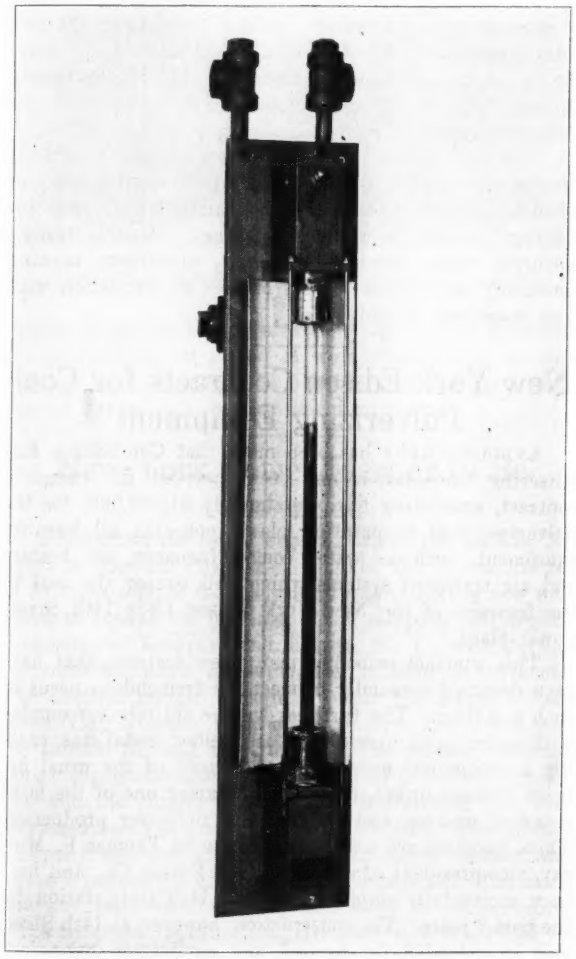


FIG. 1. COLORED LIQUID SHOWS LEVEL CLEARLY AGAINST WHITE BACKGROUND. GAGE IS PLACED AT EYE LEVEL OF OPERATORS

intervening apparatus renders the usual method inaccurate and unreliable. A colored liquid is used as an indicating medium and the gage may always be placed in any convenient location so that the line of vision is horizontal.

Steam or hot water from the boiler never reaches the instrument, thus minimizing the liability of glass breakage; this feature alone will interest engineers of high pressure plants. The indications are in no sense arbitrary but are the direct result of the head pressure of the water being measured.

Figure 1 shows one of these gages designed to operate if necessary under a pressure of over 600 lb. per sq. in. Reference to the diagram, Fig. 2, shows how this instrument is connected to a regulation boiler water column.

As shown in section, the gage consists of an upper and a lower actuating element mounted on a steel plate, the outer chambers of these elements being connected to each other with an ordinary gage glass with suitable glands and

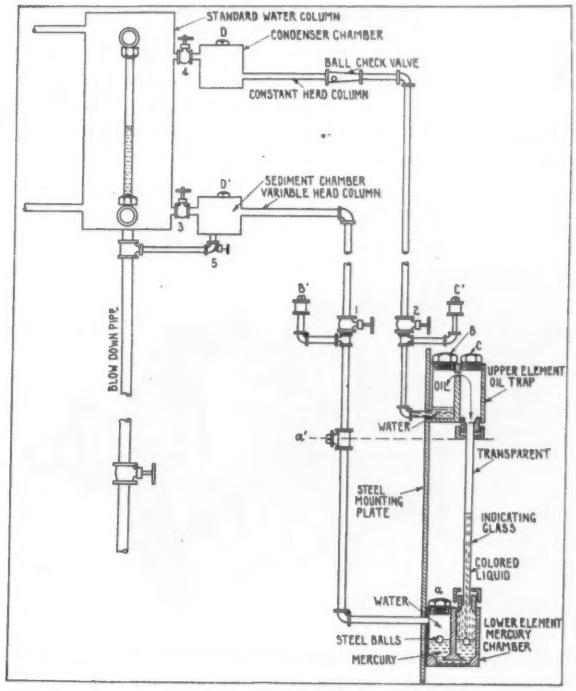


FIG. 2. SECTION OF GAGE AT RIGHT SHOWS U-TUBE AND POSITION OF THE THREE LIQUIDS. PIPING TO STANDARD WATER COLUMN PROVIDED WITH CONDENSER AND SEDIMENT CHAMBERS

stuffing-boxes. The inner chambers are connected by ½-in. pipe, as shown, to the upper and lower limits of the variable column of water to be measured.

Both the actuating elements are made from 2 by 4 by 4½-in. cold-rolled steel blocks chambered as shown. The lower element is the U-tube mercury container and is so proportioned that the volume displacement in the chamber due to a head of one inch of water in the opposite chamber will be equal to the volume of a one-inch length of gage glass. The upper element is an inverted U-tube having the same dimensions as the lower element but used as an oil trap.

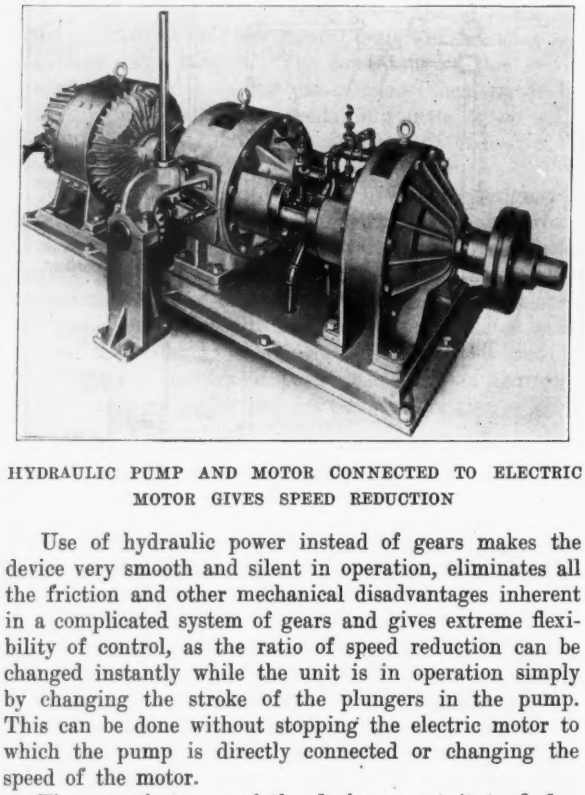
The amount of mercury used in each gage is of course governed by maximum variation of the water to be measured. With mercury standing about ¾ in. high in the chamber, if it were all forced into one chamber by a difference in pressure, a head difference of over 20 in. of water would be represented. Floating on the mercury in each chamber of the lower element is a steel ball, with its seat as shown, which acts as a check valve in case of a sudden surge or accidental breaking of the glass.

It will be noted from the foregoing that the movement of the indicating liquid need not be the same actual move-

ment as that of the liquid being measured, but may be any multiple of that movement. The McNeill liquid level gage will indicate the level in a tank 20 ft. high with a glass of any convenient length, such as 10 or 20 in., the indications being one or two inches to the foot, and it follows that this arrangement may be reversed. This instrument is being brought out by the Boiler Room Improvement Co., 549 W. Washington St., Chicago, Ill.

Speed Reduction Effected by Novel Device

NOVEL engineering practice is embodied in the use of a Hele-Shaw hydraulic pump and hydraulic motor in a speed reduction device built by the American Engineering Co., of Philadelphia, to take the place of the usual reduction gear.



HYDRAULIC PUMP AND MOTOR CONNECTED TO ELECTRIC MOTOR GIVES SPEED REDUCTION

Use of hydraulic power instead of gears makes the device very smooth and silent in operation, eliminates all the friction and other mechanical disadvantages inherent in a complicated system of gears and gives extreme flexibility of control, as the ratio of speed reduction can be changed instantly while the unit is in operation simply by changing the stroke of the plungers in the pump. This can be done without stopping the electric motor to which the pump is directly connected or changing the speed of the motor.

The manufacturers of the device expect it to find a wide field of usefulness in driving machinery where widely fluctuating resistances are encountered. When this unit is used, any unusual resistance can be dealt with by changing the ratio of speed reduction, slowing down the machine and increasing the hydraulic pressure to overcome resistance. Automatic controls can be provided to keep the speed reduction adjusted to the resistance so that the load on the electric direct-connected motor remains practically constant at all times. This frequently makes it possible to use a smaller motor for the work than otherwise would be possible.

The Hele-Shaw pump, the peculiar construction of which makes these results possible, is the heart of the device. In appearance the Hele-Shaw pump resembles an electric motor of the enclosed type. It is ruggedly built and has only 16 different parts. Oil is used as the hydraulic medium, making the pump and motor self-lubricating. No packing is needed.

Within the pump casing a cylinder body with radial cylinders rotates at constant speed around a central cylindrical valve through which the fluid passes to and from the pump. Plungers with slippers fastened to their ends are forced in and out as the slippers travel around in a groove in an outer floating ring. By shifting the position of the ring the stroke of the plungers and consequently the amount of the fluid discharged by the pump is regulated from zero to a maximum, giving a large range of speeds to any mechanism that is driven by the pump. This regulation of the plunger stroke is done while the pump is running and without changing its speed of rotation. The variable discharge drives the Hele-Shaw motor at corresponding speeds, so that it can be directly connected to any piece of machinery which it may be desired to operate at variable speed or against variable resistances. It provides a maximum reduction of 850 to 1 and a large number of lesser ratios may be instantly obtained by simply moving the control that regulates the stroke of the pump plungers.

This new device has already been adapted to a wide variety of machine drives, a few of the applications in which it already is being used as standard equipment including presses, broaching machines, planers, testing machines, cranes, mechanical stokers, oil burners, tanning machinery and a wide variety of uses in connection with deck machinery on shipboard.

New York Edison Contracts for Coal Pulverizing Equipment

ANNOUNCEMENT has been made that Combustion Engineering Corporation has been awarded the complete contract, amounting to approximately $1,000,000, for the pulverized coal preparation plant including all burning equipment, such as water cooled furnaces, air heaters and air transport systems which will convey the coal to the furnaces of the New York Edison Co.'s 14th Street power plant.

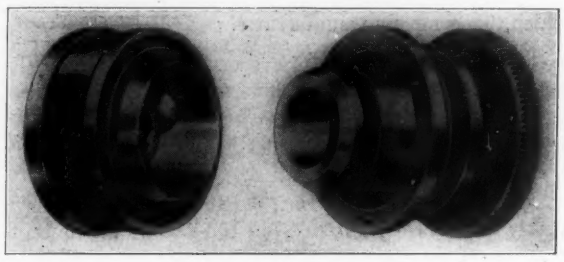
This contract embodies many new features that have been designed especially to meet the tremendous needs of such a station. The furnaces will be entirely surrounded with boiler tubes upon which are welded metal fins, making a continuous metal furnace instead of the usual fire brick furnace lining, thereby eliminating one of the large items of up-keep and maintenance in power production. These furnaces are a recent invention of Thomas E. Murray, vice-president of the New York Edison Co., and have been successfully employed in their Hell Gate station for the past 2 years. The construction, however, at 14th Street will be extended far beyond any application heretofore, as all four walls of the furnace will be made of these water tubes and the bottom will be covered with a water screen made of similar tubes, so that the coal being burned in suspension in pulverized form, the same as heavy, mechanical gas, without incident dust and dirt, will be entirely surrounded by water tubes generating steam, as well as the boiler above the furnace.

Air heaters in this plant will preheat the air for combustion and this combination of air heaters and Murray furnaces, it is expected, will make possible the continuous production of more steam per hour from these boilers than has heretofore been possible in any similar plant.

Improved Chart Hub for Recording Instruments

ONE RECENT development of the Foxboro Co. is that of an improved chart hub which cannot pinch and is so designed as to make it impossible to place a chart in any position other than on true center. The chart may be placed and then adjusted for correct time without removing the hub cap and it cannot lose its adjustment once it is set. No twisting is necessary in placing the cap. Three pins in the contact face of the cap grip the chart paper, so that turning the cap also turns the chart, thus permitting the time adjustment without removal of the cap.

The centering feature is secured by cutting a collar into the hub, over which the chart rides. The hub cap is undercut to enclose the collar edge properly and thus hold the chart firmly in place. A wide contact face, on both hub and cap eliminates the possibility of the chart buckling or assuming a concave or convex form.



HUB HOLDS CHART SO IT CANNOT LOSE ADJUSTMENT

New York Power Merger to Be Extended

FOLLOWING the recent organization of the Buffalo, Niagara & Eastern Power Co., Buffalo, N. Y., capitalized at $150,000,000, to take over local interests, it is now purposed to expand the holdings of the company and acquire properties at Lockport and Elmira, N. Y., with further contemplated plans of purchasing utilities at Syracuse. The original merger brought together the Niagara Falls Power Co., Niagara, Lockport & Ontario Power Co., and the Buffalo General Electric Co., The proposed acquisitions comprise the Lockport Light, Heat & Power Corporation and the Elmira Water, Light & Railroad Co., with combined assets approximating $12,000,000. The Elmira Company operates a 20,000-kw. generating station and serves a population of close to 75,000 persons. The third company mentioned as being interested in consolidating is the Syracuse Lighting Co., Syracuse, now controlled by the United Gas & Electric Co., Philadelphia, Pa. The new organization is said to have plans under way for extensions and improvements in existing power stations, with the installation of additional equipment.

WISCONSIN RAILWAY, LIGHT & POWER CO. is building a brick and concrete addition to its power plant at Winona, Minn., to house a new 1000 hp. Stirling boiler equipped with Westinghouse stokers raising the total boiler capacity of the plant to 2500 b.hp. Mead & Seastone, of Madison, Wis., are the consulting engineers; Worden-Allen Company, Chicago, are the contractors, and E. H. Kirchner, is chief engineer of the plant.

News Notes

THE FEDERAL POWER COMMISSION, at its meeting of May 23, authorized the issuance of a license to the Hydraulic Race Co. of Lockport, N. Y., and other affiliated corporations, for a period not to exceed 50 yr., for the diversion from the Niagara River and use of a daily average of 275 cu. ft. per sec. of water to be carried through the State Barge Canal and to be diverted above the locks at Lockport by the Hydraulic Race Co. and discharged into Eighteen Mile Creek for use by the other corporations. The project works involved in the license consist of eleven separate developments. The following licenses were also granted by the Commission: to Messrs. Pattee, Bernhard & Ross, of Oakdale and San Francisco, Calif. and Astoria, Ore., for a power project estimated to develop 5000 hp. on the North Fork of Stanislaus River, Calif.; to Stephen E. Kieffer, San Francisco, Calif., for a power project in the Cosumnes River, forming a reservoir of 470,000 acre-feet capacity; to the Ventura Power Corp., San Francisco, Calif., for a 6000 hp. project in Ventura and Los Angeles Counties, Calif.; and to the Central Carolina Power Co. of Columbia, S. C., for a project in Broad River, S. C., employing two dams and estimated to develop 15,400 hp.

ANNOUNCEMENT is made that the Fuller-Lehigh Co. has acquired all the pulverized fuel interests of The Bonnot Co., of Canton, Ohio. Under this arrangement, the Fuller-Lehigh Co. has secured the exclusive rights to the Blake water tube bottom (water screen), Blake vertical firing and Sherban and Pomeroy unit-air-ball mill, now known as the Fuller-Bonnot unit ball mill. Also, some of the engineering personnel of The Bonnot Co. has been retained by the Fuller-Lehigh Co.

ENGINEERING PUBLIC SERVICE CO. is the name of a new company formed by the syndicate headed by Stone & Webster, Inc., which recently bought control of Virginia Railway & Power Co., to acquire this and other properties. The new company is initially to own or control properties in Virginia serving Richmond, Norfolk, Portsmouth and nearby communities.

THE MT. LOGAN POWER CO., of Chillicothe O., has been incorporated by Milton J. Scott, Charles C. Jack, A. M. Renick, Walter Brewer and Hector McVicker. The capitalization is for $500,000 of preferred stock and 500 shares of no par value common stock.

THE CONVEYOR CORP. of America, Chicago, Illinois, announce the appointment of the Chicago Electric Co., 740 West Van Buren St., Chicago, as District Representatives for the sale of conveyors in Northern Illinois and Northern Indiana.

THE UEHLING INSTRUMENT CO., of Paterson, N. J., has just appointed Charles M. Bullard, Appleton, Wis., as its representative for Central and Northwestern Wisconsin, to handle its power plant instruments.

A SELF-RESETTING undervoltage device for large, solenoid operated, air circuit breakers is a new product of the General Electric Co. This device was designed so that its armature, after having tripped the breaker, is brought back to the reset position against the core until voltage returns, eliminating the necessity of hand resetting. The method followed utilizes the movement of the breaker mechanism in opening for the purpose of resetting. This undervoltage device is designed as a permanent feature of

the breaker on which it operates and is an integral part of the frame. It is made for use on breakers of 3000, 4000 and 6000 amp.

PETITIONS HAVE BEEN FILED with the City Council of Norfolk, Neb., to call an election to vote bonds in the amount of $250,000 for a municipal electric light plant. The city has retained Arthur L. Mullergren, Consulting Engineer, Gates Bldg., Kansas City, Mo., to make a complete report and estimates for this plant.

THE NATIONAL PUBLIC SERVICE CORP., operated by A. E. Fitkin & Co., New York, is disposing of a bond issue of $4,500,000, the majority of the proceeds to be used for the purchase of a controlling interest in the Municipal Service Co., including proposed extensions and betterments in the plants and system of that organization, operating the Alexandria Light & Power Co., Valdosta, Ga.; Titusville Light & Power Co., Titusville, Pa.; Glen Rock Electric Light & Power Co., Glen Rock, Pa., and other Pennsylvania and Ohio properties.

WHEELING, WEST VIRGINIA, now has in operation a completely electrified municipal filtration plant, using Worthington pumping equipment of 10, 15 and 20 million gallons capacity per day for low service, and similar capacities for high service. Three electric motors, variously rated at 225, 300 and 400-hp., drive the low service pumps, while the high service pumps are operated by a 700, a 900 and a 1300-hp. motor. All these motors are of the constant speed, slip ring, induction type. A 5-hp. induction motor operates each of the priming pumps. A 750-kv.a., 900-r.p.m., synchronous condenser with direct-connected exciter corrects the power factor for a maximum load of 1900 hp., which corresponds to the simultaneous operation of the 10 and 15 million gallon high and low service pumps.

Complete electrical, equipment, including automatic control apparatus, switchboard equipment and transformers for light and power, was furnished by the General Electric Co. A detailed analysis was made of the expense of both the steam and the electric methods of pumping, when the erection of the plant was under consideration, by the J. N. Cheser, engineers of Pittsburgh. As a result, it was estimated that the construction cost of providing a steam-driven plant was approximately $300,000 greater than that of providing an electrically-driven plant.

Catalog Notes

SCHUTTE AND KOERTING CO., of Philadelphia, Pa., are issuing a series of bulletins, describing various equipment of their manufacture. Two, which have recently been published, are Bulletin 9-M on Magnetic Oil Strainers, and Bulletin 7-E on Everdur Valves, Fittings and Jets.

GRAVER ZEOLITE WATER SOFTENERS are treated in Bulletin No. 509, recently issued by the Graver Corp., East Chicago, Ind. The bulletin deals first with hard water, water softening, and water filtering, and then takes up the specifications for the Graver zeolite water softener, describing in detail the various features of the Graver Corporation's equipment.

THE CENTURY ELECTRIC CO., of St. Louis, Mo., in an endeavor to acquaint engineers with the special features on Century motors, has recently issued a number of four page pamphlets under such headings as Split-Phase Induction Motors, Refrigeration Motors, and Repulsion Start Induction Single Phase Motors. These pamphlets illustrate and describe the construction of the armature, windings, lubrication and bearings, and special features which make the motor applicable to various services.

LEAFLET 402, just issued by the Griscom-Russell Co., of New York, describes the Reilly oil heater, which uses live steam to provide the proper degree of preheating of oil for thorough atomization at the burners.

LACLEDE-CHRISTY BULLETIN for June, 1925, issued by Laclede-Christy, St. Louis, Mo., contains a detailed discussion, together with several illustrations, of the process of molding refractories by hand.

THE DEAN HILL PUMP CO., of Anderson, Ind., has just issued a new catalog, which describes, in a general way, the complete line of centrifugal pumps and steam turbines which this company manufactures.

CHICAGO AUTOMATIC Conveyors Co., of Chicago, Ill., has recently published an illustrated folder, describing the Chicago automatic, heavy duty conveyor, illustrating some of its details and showing a number of installation views.

CHAS. CORY & SON, Inc., of New York City, has recently published Bulletin No. 103-29-B, describing the features of the Cory Recony units which are standardized in sizes to operate remotely, valves from 2 to 60 in. under varying steam and temperature conditions.

CONVEYORS CORP. OF AMERICA, Chicago, Ill., has just issued a booklet entitled "Finer and Better Coal Handling Equipment," which describes the American Mono-Rail Cable Conveyor, newly designed equipment for handling coal from railroad cars to silos, bins, bunkers or ground storage.

THE NEW STRATTON SEPARATOR is described in an information leaflet, recently issued by The Griscom-Russell Co., of New York City. This device, which has been in use on high pressure steam lines for a number of years, has been improved with a larger helical path and a spatter cap on the outlet pipe to increase the separating efficiency. The number of this leaflet is 408.

SOUTHWESTERN ENGINEERING CORP. of Los Angeles, Cal., has just issued a new bulletin, describing Collins water-tube boilers and Southwestern heating boilers. The first part of the booklet discusses fundamentals of boiler design as applied in the Collins water-tube boiler and shows details and assembly drawings. The latter part takes up the advantages of Southwestern heating boilers.

VACUUM ASH & SOOT CONVEYER CO., Newark, N. J., is distributing a new bulletin describing the Vasco system of handling ashes, soot and fine combustion dust. This system consists primarily of a tank or ash hopper in which a high vacuum is created by a steam jet, the ashes or other material being drawn from the ashpit through pipes by the suction caused by the vacuum in the tank.

MONITOR AUTOMATIC EQUIPMENT, especially for the control of newspaper and magazine printing presses and paper calendering machines, is described in Bulletin No. 108, recently issued by the Monitor Controller Co., Baltimore, Md. The bulletin takes up a brief history of the development of newspapers and newspaper printing as a mechanical art, which is followed by a detailed discussion of the Monitor system.